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ABSTRACT

The Environmental Protection Agency developed this curriculum to train technicians to monitor water quality. Graduates of the program should be able to monitor municipal, industrial, and commercial discharges; test drinking water for purity; and determine quality of aquatic environments. The program includes algebra, communication skills, biology, general chemistry, instrumentation, statistical analysis, technical report writing, and water quality control processes, laboratory management and techniques, and field experience. The curriculum format is designed around behavioral objectives defining the purpose, instructional objectives, conditions, and acceptable performance levels for each course of study. Sequences of courses, individual courses, or parts of courses can be isolated or recombined to satisfy workshops, short-training institutes, seminars, or diploma programs. Thus, a variety of pathways can be used for retraining or additional training of water quality technicians. (MR)

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A Two-Year Water Quality Monitoring Curriculum

SEPTEMBER 1975

AWARDED TO
Water Quality Monitoring Project
Ulster County Community College
Stone Ridge, New York 21484

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US Environmental Protection Agency
Washington, D.C. 20460
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Summary

This instructional program is designed to meet the needs for technicians to monitor for the National Pollutant Discharge Elimination System and Safe Drinking Water Act. In addition, it will prepare a technician to perform process control laboratory procedures for water and wastewater treatment plant operations, as well as to perform a variety of procedures required by water quality regulatory agencies.

It applies the behavioral objective format to a two-year degree program in water quality monitoring based on the on-the-job needs of water quality technicians. It provides the opportunity to construct a total learning package, including clearly defined instructional objectives, instructional guides, and audiovisual modules. The graduate will fill positions with regulatory, municipal, industrial, manufacturing, and consulting organizations. The program described could be applied to the development of curricula for a variety of environmental, health, liberal arts, and other subjects.

A Two-Year Water Quality Monitoring Curriculum

A Program Designed To Meet the Requirements
For an Associate in Applied Science Degree
At Appropriate Two-Year Colleges

Introduction

The Federal Water Pollution Act of 1972 (which established the National Pollutant Discharge Elimination System), the subsequent Safe Drinking Water Act of 1974, and the request of Congress that the Environmental Protection Agency also be responsible for the surveillance of all our waterways have brought about an unprecedented need for trained technicians who can monitor municipal, industrial, and commercial discharges; test drinking water for purity; and investigate aquatic and marine environments to determine the quality of these waters.

To meet these needs, the Environmental Protection Agency recognized it would be essential to develop a training program that would provide technicians capable of being productive immediately upon employment. To accomplish this, EPA proposed the development of a standardized two-year curriculum leading to an associate degree which would be so clearly defined that it would serve as a national standard. EPA further proposed that the curriculum be written so that a sequence of courses, one course, or parts of a course could be extracted from it and recombined to form workshops, short-training institutes, seminars, or diploma programs.

These requests provided the authors with the unique opportunity to apply the much talked about theories of behavioral objectives to the development of an entire two-year curriculum based on the objective format. The purpose of this project, therefore, was:

1. To develop a two-year curriculum in Water Quality Monitoring, leading to an Associate in Applied Science degree, in which the graduate will be productive immediately upon employment.

2. To use the format of behavioral objectives in which the curriculum has been so designed that the purpose, instructional objective, conditions, acceptable performance level, and course sequences are clearly defined. This format further provides the opportunity to describe in measurable terms the skills and knowledge to be learned while furnishing the student with a clear definition of what he must know to successfully complete the program.

3. To produce a curriculum in which the learning objectives are independent units that can be isolated and sequenced to provide a variety of instructional (critical) pathways for training technicians to do specific tasks. These pathways can be used to provide a host of workshops and training programs of varying lengths and types. These can be used in continuing education for retraining or additional training of water quality technicians.

4. To design a curriculum format from which a system of modules can be produced, thereby allowing the instructor to develop, evaluate, and use a variety of instructional strategies for any given course or objective. Additionally, when the "critical pathways" are identified and approved, appropriate instructional materials (workbooks, audiovisual materials, simulations, etc.) can be produced and made available. These pathways then can be utilized with a minimal amount of participation by instructional or supervising staff.

The curriculum developed here has all these attributes. Each course defines

itself, as well as the terminal behavior the graduate will exhibit. The curriculum is designed to produce a technician who can be employed productively in many areas of water monitoring immediately upon job entry with a minimal amount of retraining. It is a system which lends itself readily to evaluation and immediate revisions -- an idea whose time has come.

What is presented here, therefore, is a curriculum which, utilizing the concepts of instructional objectives, offers the student, faculty and institution: objectives which are clearly and specifically defined; instructional pathways for the continuing education of the technician; modular programs which can be easily identified and produced; and a curricular system in which the components or the total system can be readily evaluated.

TABLE I

Organizations Which Might Employ Graduates of Water Pollution Control Technologist Program and Their Expected Activity

Place of Employment	Activity
1. Consulting Engineers	Field survey of pollutant sources; stream survey studies; feasibility studies and reports; hydraulic studies; supervision of operation of laboratories; development of operation manuals for laboratories; public relations.
2. Government	
a. Federal	Stream surveys; laboratory analyses; public relations; assistance to plant operations staff; interpretation and enforcement of laws and regulations.
b. State	Stream surveys; laboratory analyses; public relations; assistance to plant operations staff; interpretation and enforcement of laws and regulations.
c. Municipal	Combination of consulting engineering activity and Federal activity depending on size of municipality.
d. Drainage Basin and Commissions	Combination of consulting engineering activity and Federal activity depending on size of commission.
3. Industry	Responsible charge of laboratory control of pollution abatement facilities; in-plant studies of potential pollution sources and abatement thereof; evaluation of pretreatment and direct discharge into municipal sewers; public relations; reports to management.
4. Manufacturer of Process Equipment and Chemicals	Research and development; supervision of laboratory operation of plants and instruction of plant personnel on proper laboratory operation; checking installation and operation of new and old chemical feed equipment.
5. Equipment Distribution	Research and development; supervision of laboratory operation of plants and instruction of plant personnel on proper laboratory operations; checking installation and operation of new and old chemical feed equipment.

Future Work

The completion of this curriculum has brought the use of behavioral objectives to a point where further development will not only enhance the use of this instructional format, but could also provide an educational flexibility and freedom of arrangement not available before. Unfortunately, as so often happens when putting together something like a large jigsaw puzzle, there are pieces still missing which are necessary to complete the total program. The production of self-pacing, independent instructional materials could provide the trainee with the tools necessary to assist him in learning new pathways (various sequences of courses or individual objectives), or the entire curriculum with a greater potential for success. In this way the "jigsaw puzzle" would be complete.

To reach this goal, it is strongly recommended that:

1. Instructional guides for each objective (for use by both the instructor and the student) be developed and made available. First priority should be to those objectives within the essential technical courses.

2. Instructional materials, such as modules and minicourses, be produced to implement the instructional guides. These modules should be independent, self-pacing, self-testing, and confined whenever possible to a single concept broken down into one or more learning objectives.

Completion of these instructional materials would give the instructor and trainee an "academic cafeteria" through which, by proper selection and sequencing, trainees can master the necessary skills to perform the analyses effectively or can implement their studies of the entire curriculum, thus offering them a better opportunity to complete the program successfully. Additionally, this "cafeteria" can function so that "critical pathways" (see pages 15 and 16) be selected and sequenced into a host of continuing education workshops and training courses.

It is further recommended that:

1. Additional programs in the environmental control field -- i.e., air pollution, solid waste management, and others -- be developed along lines similar to the water quality monitoring program.

2. This curriculum be continually evaluated to determine its effectiveness in producing graduates who can fill positions in the water quality monitoring field.

An important aspect of any continuation of this effort would be close coordination with similar activities producing curricula and instructional materials that could be utilized directly in or be used to give guidance to the further implementation of this technician's curriculum. A number of these efforts have produced performance-oriented course descriptions or performance-oriented instructional materials that are suitable for use in the curriculum described in this report. The following list represents some of the organizations.

Project BIOTECH
American Institute of Biological Sciences
3900 Wisconsin Avenue NW
Washington, DC 20016
(202) 244-5581

Project CIVTEC
State Board for Technical and
Comprehensive Education
1429 Senate Street
Columbia, SC 29201
(803) 758-3171

Standard Field Operation Procedures
Water Program Operations
Manpower Development Staff
National Training Center, EPA
Cincinnati, OH 45268
(513) 684-8223

Project Coordinator
TECH Physics Project
American Institute of Physics
Indiana State University
Terre Haute, IN 47804
(812) 232-6311 Ext 5355

Wastewater Technician Training (CEWT)
Manpower Training Branch
Office of Water Program Operations
Environmental Protection Agency
Washington, DC 20460
(703) 557-7363

Preprofessional Individually Paced
Instruction (PIPI)
College of Engineering
Oklahoma State University
Stillwater, OK 74074
(405) 372-6211 Ext 7551

Standard Operating Job Procedures
Pollution Abatement Technology (PAT)
Charles County Community College
LaPlata, MD 20646
(301) 934-2251

Suggestions For Implementation

PHILOSOPHY AND PURPOSE

Institutions considering the adoption of the Two-Year Water Quality Monitoring Curriculum should be convinced of the desirability and effectiveness of two-year programs. They should be aware of the need for such programs, in general, and for the water quality monitoring instructional program, in particular. Further, the institution should be oriented towards the use of specific behavioral objectives for developing instruction and evaluation programs which use this format.

Such an institution may be either public or private, profit or nonprofit, but it should have the following characteristics:

1. Place a clear emphasis on occupational preparation as one of its purposes.

2. Offer post-secondary instruction leading to an associate degree.

3. Accept students who are not high school graduates into its instructional program.

4. Offer remedial instruction, when needed, in basic education.

ADMINISTRATIVE AND INSTITUTIONAL SUPPORT

The institution must exhibit a clear interest in a water quality monitoring instructional program and be willing to provide administrative support for such a program, including adequate financial support. Funds must be budgeted for professional development of instructional staff, including opportunities for contact with other professionals at local, state, and national levels. The budget should include items for instructors' travel and participation in professional meetings on a scheduled basis. A reasonable minimum of such activities might include:

1. National meeting--annually.

2. Professional seminars--semi-annually.

3. Continuing education course(s)--annually.

4. Professional society (local) at the discretion of the instructor.

5. Seminar or short course on advances in instructional technology, including innovative teaching techniques--annually.

The institution should provide and maintain an active student personnel services department which will meet the following student needs:

1. Provide student counseling services.

2. Maintain student records.

3. Support and assist in organizing programs of student activities.

4. Furnish adequate health services.

5. Offer financial advice and assistance when needed.

6. Assist in locating student housing.

7. Provide for student testing and evaluation.

The institution should provide adequate ancillary personnel to conduct efficiently and effectively noninstructional

activities in support of the instructional program. This would include secretarial assistance and technicians to assist with laboratories (chemistry, biology, and equipment maintenance).

CURRICULUM

Suggestions for curriculum are given on pages 15 to 20. During the initiation of the program the administration should plan to reduce the workload for instructors to give them time to plan and organize the program.

Students should be permitted to learn, each at his own pace. This will mean that time requirements must be kept flexible, and adequate guidance and help provided for each student. The student should learn to take the major responsibility for planning and learning. At all times he should be a participant, not merely a spectator, in the learning process. Most students do not have these skills when they enter the program. A conscious effort must be made by the instructors if these skills are to be developed.

Instructional modules should be sized and sequenced to provide the most effective learning environment possible. The student must have continuing feedback concerning his progress to facilitate learning. Individualized instruction includes many types of learning activities which should be selected on the basis of effectiveness in achieving learning.

INSTRUCTIONAL STAFF

Instructors in the technical courses should have at least a B.S. degree and two years of full-time work experience. If such individuals are not available, those with at least six years of full-time work experience in the field would be desirable. Another alternative is to provide existing staff with background to qualify them for teaching the courses.

PHYSICAL FACILITIES

1. Technical facilities are described in Appendix IV. Water treatment facilities required for field work are described in Appendix III.

2. Adequate classroom, laboratory, storage, and noninstructional space must be available to accommodate the number of students, staff, and equipment to be housed in the area.

3. Plans should be made to expand the facilities if enrollment increases.

RECRUITMENT AND PLACEMENT

The institution should institute a plan for recruiting students. This program should cover a wide geographic area. It should include communicating with secondary schools, the general public, and various commercial and civic organizations, especially those connected with the water quality monitoring field.

Recruiting brochures, pamphlets, and announcements must be factual and accurately stated and presented in a manner that will bring credibility to the program.

Potential students should be given an orientation tour of a wastewater treatment plant prior to enrollment. This is especially important.

Admissions policies should be flexible, allowing individuals to enter who have not graduated from high school if they can demonstrate the desire and capability to succeed in the program.

Water quality control personnel should be encouraged to enroll if they are

qualified. However, there should be adequate modification of their educational program in consideration of their prior knowledge and skill.

The institution should assist the student in finding a work experience which utilizes the student's training and special capabilities in water quality monitoring. The institution should provide assistance in arranging interviews with appropriate organizations in the water quality monitoring field.

There should be a follow-up of graduates after employment to assist and counsel them in achieving advancement and to provide feedback to the institution that may help improve the instructional program.

PUBLIC RELATIONS

An adequate public relations program is essential to the success of a water quality monitoring training program. The PR program should develop close ties between the school and the community and develop support for the institution's goals. The PR program can provide information about potential applicants and the success of graduates. It can identify potential members of the institutional advisory board, as well as promote local financial support for the institution.

INSTITUTIONAL ADVISORY BOARD

The institution should establish an active advisory board. The Regional Director of EPA would be available to assist in establishing such a board. The board should assist in:

1. Recruitment of students for the program.

2. Selection of laboratory instruction sites.

3. Placement of students for in-plant laboratory instruction.

4. Placement of graduates upon completion of the program.

5. Upgrading of entrance job classification and pay scale for graduates.

6. Acceptance of the graduate by civil service systems, unions, and other employing and certifying organizations.

7. Improvement of equipment and facilities at the educational institution.

The Institutional Advisory Board should be appointed by the officials of the institution in consultation with the director of the program, officials of regional business and industries related to water quality monitoring, and the regional director of EPA. The latter should be included as a member of the board.

The Advisory Board might be composed of no fewer than seven members sufficiently representative of regional and local organizations, as well as professional groups having concern for water quality, and related occupations. The members may represent, but not be limited to, the following:

1. State agencies governing the registration and qualifications of water quality monitoring personnel.

2. State officials of water quality control authority.

3. State civil service or merit systems.

4. Unions.

5. Personnel or education committees of water quality control associations.

6. Water and wastewater laboratory equipment manufacturers and their associations.

7. Practicing water quality monitoring personnel.

8. Municipal league.

9. Professional chemists and sanitary engineers.

10. Professional educators from other institutions.

11. Local laboratory manager of cooperating water quality control facility.

12. Industries having water quality laboratory control facilities.

Each member should be appointed for a period of two or three years, in such a manner that not more than one half the members will be replaced in a single year. Members should not be precluded from service with other organizations or committees. The institution should provide the necessary funding for the meetings of the board.

Meetings should be called by the chairman not less than once each half-year. The chairman should be responsible for guiding board activities for the benefit of the program. In addition, the board should assist the institution in conducting a self-evaluation of the program and preparing a written report that describes how the institution has met the various criteria that have been set.

STUDENT CHARACTERISTICS

There are few, if any, objectively qualified measures of student characteristics that might be useful in selecting students for the program. The educational institution should develop and use objective measures in the student recruitment and selection process whenever possible. Because of the wide variety in background and experience of potential students, a great deal of flexibility must be permitted in selecting students. This document offers only general guidance in student selection. Applicants may be classified into one of four general categories: high school graduates with work experience, high school graduates without work experience, nongraduates with work experience, and nongraduates without work experience.

Applicants in each of these groups must be given special consideration in selecting them for admission, as well as in planning their instruction. Each applicant should be screened on the basis of the following characteristics:

1. Evidence of academic ability: There should be adequate evidence either from school reports, entry tests, or in-depth interviews, that the student is able and interested in a career in water quality monitoring.

2. Aptitudes: Information on aptitudes might be obtained from simple performance tests, giving particular attention to motor coordination, ability to use analytical instruments, reasonable visual and auditory acuity, and the ability to identify such odors as H_2S, chlorine, and other odors commonly found in treatment plants.

3. Interests: A student should be interested in maintaining the quality of his environment, in applied science, particularly as it relates to water quality monitoring operations, and in public service that frequently involves less prestige and influence.

4. Temperament: The student should be able to get along well with others both as a supervisor and a subordinate. He should be responsible in the face of political, regulatory, and public scrutiny and criticism. He must maintain quality performance in highly repetitive, routine procedures. He must be willing to accept the responsibility for the safety and welfare of himself, his fellow workers, and the general public.

5. Physical capability and sensitivity: The student should be able to perform the necessary tasks related to water quality monitoring procedures. He must be able and willing to work in closed places for long periods of time and to spend much of his time either indoors or outdoors, depending upon the type of plant in which he will work. He must be able to work in wide ranges of temperature and in unpleasant surroundings. He cannot have allergies or personal dislikes that might prevent him from working in areas where dust, odors, fumes, and toxic odors might be present.

In the course of interviewing and testing applicants, it will sometimes become obvious that the applicant is capable of a much higher level of education and work than that offered by the water quality monitoring program. In such cases the applicant (or student) should be counseled and provided assistance, if he wishes it, to find opportunities that better suit his qualifications.

The graduate of a two-year post high school water quality monitoring instructional program will have hands-on skill and knowledge concerning laboratory monitoring in the water quality control field. He will be able, with confidence and relative ease, to adapt the specific skill and knowledge he has acquired through the instructional program to other analyses and procedures not taught directly in the program. General statements of the skill and knowledge he has acquired may be found in the course descriptions (pages 29 to 102).

Graduates should be regarded as technicians and paraprofessionals. This implies competence involving hands-on levels of application in performing most of the basic procedures in the overall operation of a water quality monitoring program.

Although the program graduate at the outset of his employment may perform basic tasks and serve brief periods in a variety of jobs and at various levels of responsibility, his terms of employment and job title should clearly indicate his internship. Remuneration, advancement, and other employment advantages should reflect the special skills and knowledge acquired during his educational program.

List of Courses

There are seventeen courses in this curriculum. The courses are listed below. A three-credit social science course and nine elective credits are also to be included in the curriculum; however, the content and structuring of these courses must be developed by the individual instructor or the department. (For lists of the courses by semesters and by course groupings, see pages 24 and 25.)

TITLE	PAGE
College Algebra (Math. 101)	43
Communication Skills (Eng. 101)	53
Environment and Life (Bio. 101)	39
General Chemistry I (Chem. 101)	29
General Chemistry II (Chem. 102)	57
Instrumentation (Chem. 201)	85
Statistical Analysis (Math. 102)	63
Technical Report Writing (Eng. 102)	91
Water Quality Control Processes (Env. Sci. 103)	73
Water Quality Laboratory Management I (Env. Sci. 203)	89
Water Quality Laboratory Management II (Env. Sci. 204)	99
Water Quality Laboratory Techniques I (Env. Sci. 101)	49
Water Quality Laboratory Techniques II (Env. Sci. 102)	69
Water Quality Laboratory Techniques III (Env. Sci. 201)	81
Water Quality Laboratory Techniques IV (Env. Sci. 202)	95
Water Quality Laboratory Techniques V (Env. Sci. 205)	101
Water Quality Summer Laboratory Experience (Env. Sci. 104)	77

Alternative Approaches To Curriculum Use

INTRODUCTION

The behavioral objective format of this curriculum offers instructors and curriculum developers the flexibility to develop a multitude of pathways--to meet varying or changing training and technician needs--that cannot be developed using the classical course description approach. These pathways enable students to enter and proceed through the curriculum from different entry points, or to obtain partial skills which may not lead to a degree but will still make the individual employable or more useful in his occupation. Some of these alternate approaches are discussed below.

COMPLETE CURRICULUM

The sequence in which each course in each subject area should be taken and the relationship of one subject area and course to another are noted in Figure 1 (page 17). The service courses in Chemistry, Biology, Mathematics, and English are to be taken in the semester prior to the one in which mastery of the subject area is needed for the Environmental Science sequence. The social science course and the electives can be taken wherever it best fits into the student's two-year schedule.

In all subsequent examples the trainee must meet required prerequisites or demonstrate mastery of the skills at the performance level indicated in the individual curriculum courses.

ENTRY WITH ASSOCIATE DEGREE IN THE SCIENCES OR RELATED FIELDS

An entering trainee with an associate degree in the sciences or related fields should be allowed credit for all courses successfully completed. An example of this would be a prior degree in chemical technology as illustrated in Figure 2 (page 18). Thus, a program can be designed to provide entering trainees with the knowledge and skills necessary to complete the Environmental Science sequence in about one year.

ENTRY FOR TREATMENT PLANT OPERATOR

The program offers the treatment plant operator the opportunity to develop his knowledge and skills in the laboratory control area without having to complete the entire degree sequence. Figure 3 (page 19) suggests a sequence for obtaining these skills.

The material in Environmental Science 104 could be mastered in the trainee's lab at any time during the training program. The trainee can proceed through both stems simultaneously. Because of prior experience, many operators may be able to omit Environmental Science 103.

ENTRY FOR SPECIFIC TASKS

Because it stands as an independent unit, each objective can be isolated and sequenced to provide a variety of instructional (critical) pathways for training technicians to do specific tasks. For instance, two of the major areas required in the NPDES monitoring program are the determination of indicator organisms (namely fecal and total coliforms and fecal streptococci) and nutrient analyses of organic and Kjeldahl nitrogen, ammonia, nitrate, nitrite, orthophosphate, and total phosphorous. If it becomes necessary to

train a technician to do these basic tests, or conversely if a technician on his own desires to learn how to do these tasks, he can be prepared or can prepare himself by selecting those objectives which pertain to mastering the techniques as noted in Figure 4. ("Math 101 12" indicates objective 12 of the course Mathematics 101, which can be found on page 44; "Chem. 101 45 ajl" indicates objective 45, parts a, j, and l, of the course Chemistry 101, which can be found on page 29.)

By proper selection and sequencing, the trainee can master these analyses in an extremely short time compared with the normal two-year requirement to complete the entire curriculum. Additionally, if appropriate instructional materials are available for each objective, then the pathways can become a self-learning program requiring minimal participation by the instructional or supervising staff.

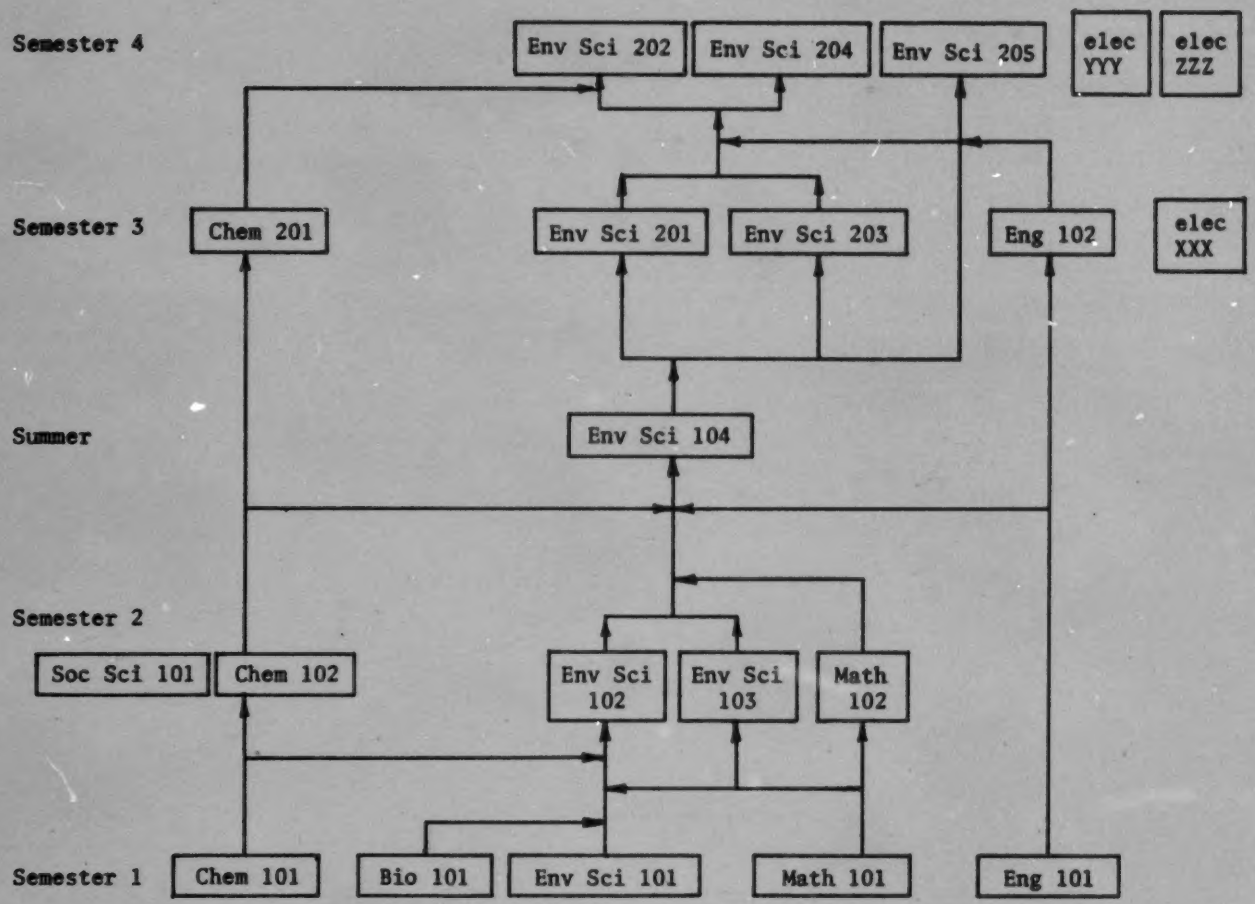
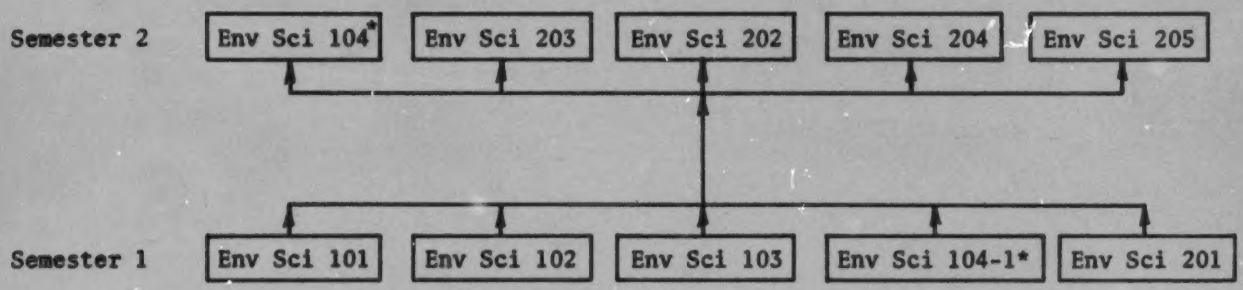


FIGURE 1
Course Sequence and Subject Area Relationship



*Env Sci 104 is divided so that 1 credit hour is taken the first semester and 2 credit hours the second semester. Alternatively, the course could be taken during the regular summer practicum at the end of the second semester, or it could be taken as an independent study course consisting of part-time work in a treatment plant during the school year.

FIGURE 2
Entry with Associate Degree in the Sciences or Related Fields

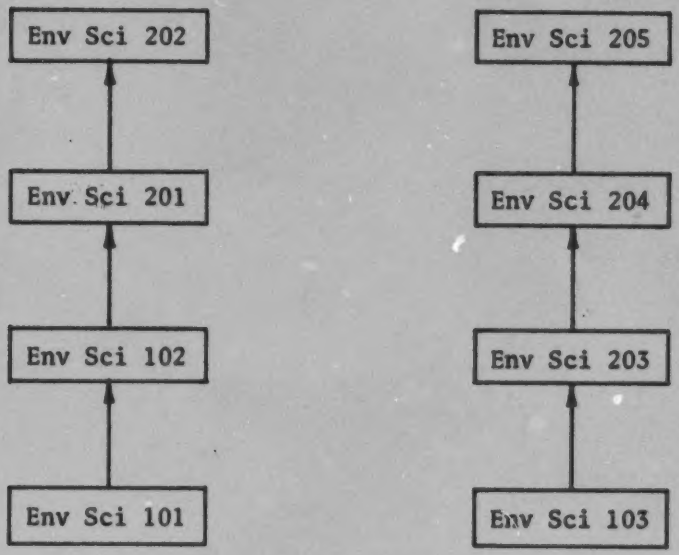


FIGURE 3
Entry for Treatment Plant Operator

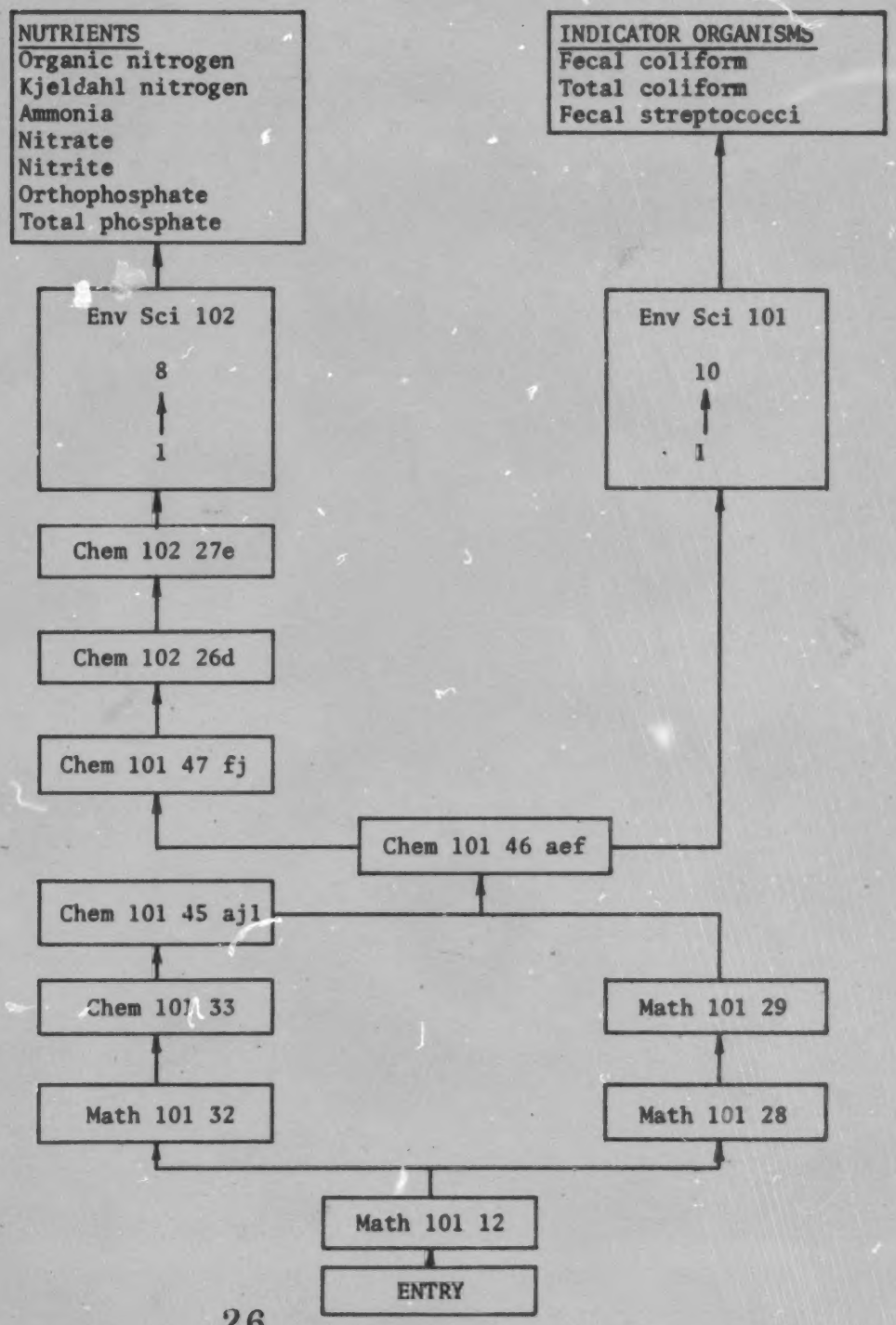


FIGURE 4
Suggested Sequence of Specific Objectives To Prepare Technician For Analyses of Nutrients and Indicator Organisms

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Curriculum

Instructor's Note

Each course in this curriculum is introduced with a statement of purpose and then broken down into a number of units of instruction, each containing an objective (OBJ), learning conditions (COND), and a performance level (PL).

The statement of purpose is a synopsis of the course material and explains what the student will be studying. It deals with the relevance of the subject material and explains why the student is to master the course skills and knowledge covered in the course. The student should understand why he should master the learning objectives and how the course fits into the total sequence of his learning.

The OBJ tells the student precisely what he must be able to do after mastering the unit of instruction.

The COND tells the student (and the instructor) the circumstances under which the student will perform, or the objects, information, or assistance the student will have access to while performing. The student should perform under conditions as close to real situations as is practical in the instructional situation.

The PL tells the student the acceptable level of performance that will be required of him to demonstrate mastery of the objective.

TABLE II
Course Groupings

Course	Title	Credits
Chem. 101	General Chemistry I	4
Chem. 102	General Chemistry II	4
Chem. 201	Instrumentation	4
	Total Chemistry Credits	12
Math. 101	College Algebra	3
Math. 102	Statistical Analysis	3
	Total Mathematics Credits	6
Bio. 101	Environment & Life	4
	Total Biology Credits	4
Env. Sci. 101	Water Quality Laboratory Techniques I	3
Env. Sci. 102	Water Quality Laboratory Techniques II	3
Env. Sci. 103	Water Quality Control Processes	3
Env. Sci. 104	Water Quality Summer Laboratory Experience	3
Env. Sci. 201	Water Quality Laboratory Techniques III	3
Env. Sci. 202	Water Quality Laboratory Techniques IV	3
Env. Sci. 203	Water Quality Laboratory Management I	3
Env. Sci. 204	Water Quality Laboratory Management II	3
Env. Sci. 205	Water Quality Laboratory Techniques V	3
	Total Environmental Science Credits	27
Eng. 101	Communication Skills	3
Eng. 102	Technical Report Writing	2
	Total English Credits	5
Soc. Sci. 101	Social Science	3
	Total Social Science Credits	3
Elective (Optional)	Total Elective Credits	9
	Total Curriculum Credits	66

TABLE III
Semester Outline

Year	Semester	Course	Title	Credits
I	I	Chem. 101	General Chemistry I	4
		Bio. 101	Environment & Life	4
		Math. 101	College Algebra	3
		Env. Sci. 101	Water Quality Laboratory Techniques I	3
		Eng. 101	Communication Skills	3
				17
I	II	Chem. 102	General Chemistry II	4
		Math. 102	Statistical Analysis	3
		Soc. Sci. 101	Social Science	3
		Env. Sci. 102	Water Quality Laboratory Techniques II	3
		Env. Sci. 103	Water Quality Control Processes	3
				16
Summer		Env. Sci. 104	Water Quality Laboratory Experience	3
				3
II	III	Env. Sci. 201	Water Quality Laboratory Techniques III	3
		Chem. 201	Instrumentation	4
		Env. Sci. 203	Water Quality Laboratory Management I	3
		Eng. 102	Technical Report Writing	2
		Elective (Optional)		3
				15
II	IV	Env. Sci. 202	Water Quality Laboratory Techniques IV	3
		Env. Sci. 204	Water Quality Laboratory Management II	3
		Env. Sci. 205	Water Quality Laboratory Techniques V	3
		Elective (Optional)		6
				15

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Semester I

Chemistry 101

4 CREDITS

GENERAL CHEMISTRY I

The purpose of this course is to assist the student in learning the fundamental principles of chemistry and their applications. The student will study the application of scientific methodology; physical and chemical properties of matter; the atomic model; mole concept; chemical bonding; types of chemical reactions; principles of stoichiometry; nature of solutions; and the states of matter. The laboratory exercises will demonstrate the above and allow the student to use balances; volumetric glassware, including burets in titrations; gas collection equipment; burners; and thermometers.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ

Define:

Chemistry	Hypothesis
Science	Law
Fact	Theory

COND

From recall.

PL

Five of six correct.

2

OBJ

Discuss in essay form and demonstrate the application of the "scientific method."

COND

Given a set of observations, interpret these to project a hypothesis, then describe or take further steps to verify or change the hypothesis.

PL

Two correct answers in three examples. Correct answers must include a hypothesis, further suggested steps, and predicted results of these steps.

3

OBJ

Describe and demonstrate the proper use of a Bunsen burner (or an equivalent) to give a hot flame.

COND

Given an unlighted, unadjusted burner and a match or striker.

PL

A clear blue cone must be observable with no sustained yellow in the flame. A piece of soft glass must glow yellow in five seconds or less at the tip of the blue cone. Identify the cool, hot, and hottest regions of the flame.

4

OBJ

Describe and demonstrate the correct method for cutting, bending, and fire-polishing a piece of glass tubing. Explain why these steps are performed.

COND

Given a burner, wing tip, triangular file, 10 inches of soft glass tubing, and an asbestos pad.

PL

The glass tubing must be scratched with one firm stroke of the file, leaving a clearly visible scratch, then smoothly broken with thumbs placed opposite the scratch. Fire-polishing must leave no roughness or constrictions. A simple bend to $90^{\circ} \pm 10^{\circ}$ with no visible constrictions, flattening, or dislocations from the plane of the bend. Also, neither student, instructor, nor table top must be burned with hot glass. The entire operation must require no more than 15 minutes.

5

OBJ

Define and identify from samples of substances:

a. The stage (solid, liquid, gas) of each sample.

b. Its physical and chemical properties.

c. Its extrinsic and intrinsic properties.

COND

Define from recall. Identify when given several samples and appropriate test equipment (burner, knife, hammer).

PL

90% correct. Included should be:

a. Whether the state has either fixed volume or fixed shape.

b. To measure chemical properties, one must change the substance under study.

c. Intrinsic properties are characteristic of the substance, not its size or shape.

6

OBJ

Differentiate between:

a. Mixtures and pure substances.

b. Homogeneous and heterogeneous mixtures.

COND

Given samples of each, using sight and touch.

PL

100% correct, using samples which are clearly one or the other.

7

OBJ

State the physical properties expected for metals and identify the metals in a group of substances.

COND

State from recall. Identify when given a group of samples, including metals, nonmetals, crystalline compounds, and waxy compounds.

PL

Select all the metals and none of the other samples.

8

OBJ

Define:

Element	Neutron
Atom	Proton
Mole	Mass number
Ionization	Atomic number
Ionization potential	Isotope
Electron	Period
Energy	Group
	Nucleus

COND

From recall.

PL

80% correct, including the charge on the electron, proton, neutron, and nucleus.

9

OBJ

State the number of protons, electrons and neutrons in an atom of any given element.

COND

Using periodic chart and given the name and symbol of any element.

PL

100% correct, including the number of neutrons in any element using the average mass number for that element.

10

OBJ

Describe the periodicity of the elements.

COND

Using the periodic chart and recall of trends within the periodic chart.

PL

Discussion must include variations in radii of atoms, physical properties of metals and nonmetals, and ionization potentials with atomic number.

11

OBJ

Draw Bohr, or planetary, diagrams for any elements.

COND

Using the periodic chart.

PL

100% correct. Use only the first 20 elements until more detail of atomic structure is studied. Diagrams must indicate which are the 1st, 2nd, 3rd, and 4th energy levels.

12

OBJ

Describe, in essay form, the atomic and electrostatic basis for the periodic variation in atomic radius and ionization potential with atomic number.

COND

Using the periodic chart.

PL

Discussion must include:

a. The concept that attractive forces between charges increase with the strength of the charge and decrease with distance.

b. The effect of this concept upon the size and ionization potential of atoms.

c. The concept that distance from nucleus to electrons increases as additional shells are added.

13

OBJ

Given the names and symbols of two or more elements, predict their relative atomic radii and relative ionization potentials.

COND

Using the periodic chart.

PL

90% correct. Care must be taken to never give atoms with conflicting trends; e.g., Na vs. Se.

14

OBJ

Describe what "quantized" energy levels mean for an atom, and using diagrams of atoms and line spectra, relate these energy levels to spectroscopy.

COND

Given Bohr diagrams of atoms and pictures or drawings of line spectra.

PL

Description must relate the difference in energy between the energy levels to the light emitted or absorbed in the spectrum, stating that light or energy is absorbed when the electron moves to a higher level and that light is emitted as an electron falls to a lower energy level.

15

OBJ

Describe, using diagrams or models, s, p, d, and f orbitals for atoms.

COND

Given diagrams or models of the orbitals.

PL

Select the correct model in each case and state that the model describes only the most likely "path" or region of space occupied by the electron about the nucleus. Also, state the number of orbitals of each type in each shell and the maximum number of electrons which can occupy each orbital.

16

OBJ

Describe the "build-up" (Aufbau) principle and use this principle to predict the spectroscopic shorthand(e.g., $1s^2$ $2s^2$ $2p^1$ for boron) for the electronic arrangement of atoms.

COND

Using the periodic chart.

PL

80% must be correct as predicted by the principle. (Some atoms do not follow the build-up exactly, but these differences will lead to logical errors of ± one electron and will be acceptable.)

17

OBJ

Identify that portion of the periodic chart which represents a given orbital arrangement.

COND

Given the periodic chart.

PL

100% correct, identifying Group 1A as s^1, IIIA as s^2p^1, etc.

18

OBJ

Predict the ionic charges of elements.

COND

Using the periodic chart.

PL

80% correct for the regular elements in simple binary compounds.

19

OBJ

Differentiate between ionic charges and oxidation states, and determine the oxidation state of each element in a given compound.

COND

Using the periodic chart.

PL

70% correct, using the regular elements to determine the oxidation states of the transition metals, etc.

20

OBJ

State (or list) the ionic charge and formula for the common radicals or complex ions.

COND

Given the periodic chart and names of the complex ions.

PL

100% correct. List must include at least the following ions: NH_4^+; NO_3^-; NO_2^-; SO_3^{-2}; PO_4^{-3}; CO_3^{-2}; $C_2H_3O_2^-$; ClO_3^-; OH^-; HCO_3^-; $H_2PO_4^-$; HPO_4^{-2}.

21

OBJ

Illustrate, using diagrams or models, the sp, sp^2, and sp^3 hybrid orbitals for an atom in a molecule.

COND

From recall.

PL

100% correct. Illustration must include a prediction of the bond angle.

22

OBJ

Illustrate, using diagrams or models, the difference between σ and π bonding.

COND

From recall.

PL

100% correct.

23

OBJ

Illustrate, using diagrams or models, the overlap of orbitals in the bonding of N_2, F_2, H_2O, NH_3, CH_4, C_2H_6, C_2H_4, O_2, and N_2.

COND

Given the periodic chart.

PL

70% correct, indicating the correct atomic or hybrid orbitals involved in the overlap.

24

OBJ

Describe:

a. Ionic bonding and ionic compounds

b. Covalent bonding.
c. Coordinate covalent bonding.
d. Polar covalent bonding, including the effect of polarity on physical properties of molecules.
e. Metals and metallic bonding.

COND
From recall.

PL
Description must include the forces involved in ionic attractions and shared electrons.

25

OBJ
Predict relative values of electronegativity and electron affinity for the elements.

COND
Using the periodic chart.

PL
The order F > O > Cl > N must always be correct; all others must be correct 70% of the time if no conflicting trends are given.

26

OBJ
Describe the kinetic molecular theory of matter.

COND
From recall.

PL
Description must include four of the following five concepts:
a. Molecules of a gas are widely separated in space.
b. They travel in straight paths.
c. They have perfectly elastic collisions.
d. They increase in average velocity with an increase in temperature.
e. All gases have the same average kinetic energy at any given temperature.

27

OBJ
Express the equation of state for an ideal gas, and use the equation to calculate volume, pressure, temperature, density, weight, or molecular weight of a gas.

COND
Given all values except the one to be calculated.

PL
Calculations must be correct 80% of the time.

28

OBJ
Discuss the nature of:
a. Solids - contrasting ionic and covalent solids with respect to lattice energy, melting point, and sublimation.
b. Liquids - including descriptions of van der Waals forces and vapor pressure.
c. Equilibrium between states of matter, such as melting vaporization and sublimation.

COND
From recall.

PL
At least 80% of the concepts must be described, with emphasis on the reversibility of changes between states.

29

OBJ
Describe the nature of hydrogen bonding and the effects of hydrogen bonding upon the physical properties of water.

COND
From recall.

PL
Description must include:
a. The molecular causes of hydrogen bonding, polarity, and bond angle.
b. Statement that the intermolecular forces resulting are weaker than ionic bonding, stronger than van der Waals forces.
c. The effects upon the properties of water (boiling point, vapor pressure,

freezing point, and density) with changes in temperature.

30

OBJ

Draw electron-dot (Lewis) diagrams for simple covalent compounds or complex ions, and use these diagrams to predict the hybridization and bond angle about any given atom in the molecule or ion.

COND

Using the periodic chart.

PL

Diagrams and hybridization predictions must be correct 70% of the time, and the bond angle should be ± 5° of the correct value. Simple compounds should be used, such as H_2O, NH_3, CO_2, N_2, HNO_3, SO_4^{-2}, CH_4, C_2H_4.

31

OBJ

Describe the nature of solutions of solids, liquids, and gases in liquids.

COND

From recall.

PL

Description must include the effects of:

a. Lattice energy of solids.
b. Solvation energy.
c. Van der Waals forces.
d. Entropy.
e. Temperature.
f. Hydrogen bonding.
g. The relationship between a saturated solution and equilibrium.

32

OBJ

Describe, using diagrams and equations, the nature of an electrolytic solution.

COND

Using the periodic chart.

PL

Description must include:

a. How electricity is carried through an electrolytic solution.

b. How electrolytes are formed from ionic compounds and from polar covalent compounds.

c. The chemical changes which occur at the cathole and the anode during electrolysis.

33

OBJ

Identify simple chemical compounds when given the symbol or name.

COND

Using the periodic chart.

PL

70% correct, using common binary and ternary compounds. Special emphasis should be placed on the chemicals used in NPDES tests.

34

OBJ

State and discuss the Law of Conservation of Matter.

COND

Given a physical, chemical, or biological system, and the periodic chart.

PL

Law must be illustrated as a mass balance using a balanced equation or similar system.

35

OBJ

Balance both simple and redox chemical equations.

COND

Using the periodic chart and given complete but unbalanced chemical equations.

PL

70% of the equations must be balanced correctly.

36

OBJ

Define and use: gram atomic weight, molecular weight, formula weight, mole, and Avagadro's number.

COND
Using the periodic chart.

PL
Use of these terms must include calculations and essay-type descriptions, using examples of the relationship between grams, moles, and Avagadro's number.

37

OBJ
Use the metric system of measurement and convert between the English and metric systems of measurement.

COND
Using available reference materials.

PL
80% correct. Conversion factors must be used for length, mass, and volume.

38

OBJ
Calculate the weights of all reactants and products in a chemical equation.

COND
Given the weight of any reactant or product, the balanced equation, and the periodic chart.

PL
80% correct.

39

OBJ
Discuss, using equations, the Bronsted theory of acids and bases.

COND
From recall.

PL
Discussion must include the nature of the hydronium ion, conjugate acids, and conjugate bases.

40

OBJ
Select from a list of acids and bases the strongest acid or base of the group.

COND
Using the periodic chart.

PL
Lists of binary acids and ternary acids should be considered separately, with 80% selected correctly within these lists.

41

OBJ
Predict the products of reactions between the following and write complete and balanced equations for these reactions:

a. Oxides and water.
b. Heating active metals and nonmetals with oxygen or in hydrogen.
c. Decomposition, by heating, of $KClO_3$, H_2O_2, $NaNO_3$, $CaCO_3$.
d. Acids and bases.
e. Displacement of hydrogen or metals from compounds by more active metals.

COND
Using the periodic chart and the activity series of metals.

PL
Predictions of products must be correct 80% of the time.

42

OBJ
Describe how the addition of solute to solvent affects each of the following and cite how each can be used personally, industrially, or to solve or cause an environmental problem:

a. Freezing point.
b. Boiling point.
c. Vapor pressure.
d. Osmotic pressure.

COND
From recall.

PL
Descriptions should include the nature (e.g., lowering of freezing point), and molecular reasons for the effect.

43

OBJ

State the First Law of Thermodynamics using thermodynamic symbols, and show how this expresses the conservation of energy.

COND

From recall.

PL

Definition and example must be used to relate the First Law to the conservation of energy.

44

OBJ

Describe the concepts of entropy, enthalpy, and free energy.

COND

Given a change or equation.

PL

Description must include:

a. Changes of state.
b. Formation of solutions.
c. Chemical reactions (e.g., combustion of fuels, biodegradation, and photosynthesis).

45

OBJ

Do calculations involving:

a. Exponential numbers.
b. Per cent error.
c. Density.
d. Specific heat.
e. Heats of fusion and vaporization.
f. Mole ratios and empirical formulae.
g. Gaseous diffusion.
h. Per cent by weight or volume for solutions.
i. Molarity.
j. Normality and equivalent weights.
k. Molality.
l. Milligrams per liter and parts per million.
m. Colligative properties.
n. Theoretical yield and per cent yield in a reaction.
o. Free energy, entropy, and enthalpy changes.
p. Molecular weights, using gas laws or colligative properties.

COND

Using the periodic chart and given appropriate data.

PL

All calculations must be done using exponentials, and answers must be rounded off to the correct number of significant digits.

46

OBJ

Demonstrate the use of the following equipment:

a. Bunsen burner.
b. Thermometer.
c. Barometer.
d. Metric rulers.
e. Volumetric glassware.
f. Balances.

COND

From recall, given an equipped laboratory.

PL

Each must be used accurately to within the tolerance of the equipment and must be left as clean as before it was used.

47

OBJ

Demonstrate the following laboratory techniques:

a. Separate solids from liquids using a filter.
b. Determine the density of a regular and an irregular shaped object using dimension measurement and volume displacement.
c. Perform quantitative chemical reactions, calculating per cent yield of products.
d. Determine the molecular weight of a volatile liquid using gas laws.
e. Determine the length of a molecule by the immiscible layer technique.
f. Determine the equivalent weight

or concentration of reactants by acid-base titrations.

g. Determine the molecular weight of a solute by colligative properties of solutions.

h. Determine the heat of a reaction.

i. Determine the relative rates of diffusion of HCl and NH_3.

j. Prepare standard solutions of known concentration.

k. Determine the empirical formula for a compound.

l. Verify the gas laws using a tightly stoppered syringe.

COND

Given an equipped laboratory, appropriate chemicals, and an instruction sheet.

PL

(a)	A clear filtrate must be obtained.
(b-e)	± 10% of the correct value.
(f)	± 3% of the correct value.
(g-i)	± 10% of the correct value.
(j)	± 1% of the correct value.
(k-l)	± 10% of the correct value.

Biology 101

4 CREDITS

ENVIRONMENT AND LIFE

The purpose of this course is to assist the student in learning the major principles and facts of modern biology; their application to the creation and solution of environmental problems; and the diversity, adaptations, evolution, and ecological relationships of living things. There will be studies of the molecular, cellular, organismal, and population levels of biological organization, including interrelationships, the cyclic use of matter, and the interactions between plants and animals. Environmental relationships--particularly in relation to man and nature and mankind's present predicament with population, pollution, and conservation problems--will be studied. Laboratory exercises will demonstrate the above and allow the student both to apply these principles and to identify and use basic biological instrumentation.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ

Compare in essay form or orally a hypothesis and a theory as related to biological systems.

COND

From recall.

PL

Statement must include an example of a hypothesis and a law, and how they differ and relate to each other.

2

OBJ

List and discuss six general characteristics of living things.

COND

From recall.

PL

Discussion must include how specific organization, metabolism, irritability, growth, reproduction, and adaptation play a role in living things.

3

OBJ

Discuss man's dependence on water and why water is essential to living things.

COND

From recall.

PL

Discussion must include that water is a major component of cells, its importance in photosynthesis, evaporation as a cooling process, and the ability of water to act as a universal solvent.

4

OBJ

Define and describe the function of:

a. Protein.
b. Fat.
c. Carbohydrate.
d. Nucleic acid.
e. Steroids.

COND

From recall.

PL

Four out of five correct.

5

OBJ

Define and compare diffusion and osmosis.

COND

From recall.

PL

Definition must include molecular (Brownian) movement, the movement of molecules from a gradient of greater density to one of lesser density, and

the role of a selectively permeable membrane.

6

OBJ

Describe the function of the mitochondria, lysosomes, ribosomes, endoplasmic reticulum, and Golgi apparatus in relation to cell function.

COND

From recall.

PL

80% of the functions must be described.

7

OBJ

Describe the relationship between proteins and enzymes.

COND

From recall.

PL

Description must include the structure and synthesis of proteins, and the properties, cellular location, and mode of action of enzymes.

8

OBJ

Using illustrations, describe the major structural and functional differences between plant and animal cells.

COND

From recall.

PL

80% of the differences must be described. Description must include differences in the cell wall and membrane, vacuoles, metabolism, and genetics.

9

OBJ

Using a moss plant as an example, describe with illustrations the development of gametophytic and sporophytic generations.

COND

From recall.

PL

Discussions and illustrations must include:

a. Gametogenesis and sporogenesis.

b. Formation of the zygote.

c. Identification of cells, both haploid and diploid.

d. Identification of the two generations with their corresponding chromosome numbers in the life cycle.

e. Relation between evolution and increasing plant complexity.

10

OBJ

Using illustrations, discuss the role of bacteria in the carbon and nitrogen cycle.

COND

From recall.

PL

Discussions and illustrations must include the role played by decay bacteria in converting carbon compounds to carbon dioxide and the nitrogen of proteins into ammonia. This must include the role of decomposing and denitrifying bacteria.

11

OBJ

Using illustrations, discuss the differences between energy cycles and matter cycles.

COND

From recall.

PL

Discussion must include:

a. That the cycles of most matter are closed.

b. To keep matter cycles operative does not require new matter.

c. Matter cycles do require new energy.

d. Energy cycles are not closed ones.

e. The first and second laws of thermodynamics.

12

OBJ

Discuss the differences and relationships between: zooplankton, phytoplankton, ichthyoplankton and nekton.

COND

From recall.

PL

Discussion must include the phylogenetic relationships, location, and environmental relationships.

13

OBJ

Perform a controlled laboratory experiment using one experimental factor. Describe how the experiment is designed, kept free of bias, quantitative information collected and analyzed, and a hypothesis formed from the experimental results.

COND

Given an equipped biology laboratory or greenhouse.

PL

Experimental subject must show a marked difference from the control. The control must remain constant and stable. The hypotheses formed must reflect the data collected and analyzed.

14

OBJ

Set up a basic laboratory test for obtaining a pure culture of bacteria from a water sample. This must include making agar, pouring plates, streaking, incubation, and identification of selected lactose fermenters.

COND

Using an equipped microbiology laboratory.

PL

Final culture must consist of only one bacterial form. The plate streak and identification must conform to set bacteriological standards.

15

OBJ

Show by a flow diagram how the photosynthetic reaction takes place, including the light and dark reactions and the end products.

COND

From recall.

PL

Discussion must include:

a. Incorporation of CO_2 into organic materials (dark reaction).

b. The conversion of radiant energy into chemical energy (ATP and NADPH).

c. The role of the chloroplast.

d. A diagrammatic flow representation of the photosynthetic reaction.

e. The end products.

16

OBJ

Perform a laboratory experiment that demonstrates the process of diffusion and the importance of inactive transport with respect to cellular energy expenditure.

COND

Using an equipped laboratory.

PL

Experiment must involve the movement of molecules from one gradient density to another without the addition of any outside energy.

17

OBJ

Using a pyramid of numbers, graphically represent a 10% yield from the producer (a biomass of 1,000 pounds of green algae) to the ultimate consumer in a pyramid of three trophic levels. Compare this pyramid with one in which the producer is the same but there is only one consumer and a 0.1% yield. Discuss how this affects the availability of food on growing populations (primarily man).

COND

Using any appropriate books or instructional material available.

PL

Discussion must include:

a. The energy loss in biomass.

b. The final weight of the biomass of the final consumer.

c. A block graph illustrating, to scale, the changes in the biomass at three successive trophic levels.

18

OBJ

Compare (using diagrams) the gross structure of a terrestrial ecosystem (a forest) and an open fresh-water ecosystem. Include the location and function of abiotic substances, producers, microconsumers, macroconsumers, and decomposers.

COND

Using any appropriate books or instructional material available.

PL

Diagrams must include:

a. Examples of organisms in each trophic level for both ecosystems.

b. The trophic levels of these organisms.

c. The function of these organisms in their respective ecosystems.

19

OBJ

Describe in essay form what sources of energy can be tapped to supply the increasing needs of the ever-growing human population with the least harmful effects on the environment.

COND

Using any appropriate books or instructional material available.

PL

Discussion must include renewable and nonrenewable resources and the chemical, biological, or energy change or transfers which occur and which may act as pollutants.

20

OBJ

Describe by the use of biogeochemical cycles how man's disposal practices have had a detrimental effect on these cycles, man, and his environment.

COND

Using any appropriate books or instructional material available.

PL

Discussion must include:

a. At least three biogeochemical cycles listed below and the effect of the interruption of these cycles by man-made pollutants due to waste disposal.

1. Water
2. Carbon
3. Nitrogen
4. Sulfur
5. Phosphorus

b. The effect the interruptions of these cycles have on the environment and man's quality of life.

Mathematics 101
3 CREDITS

COLLEGE ALGEBRA

The purpose of this course is to assist the student in learning the fundamentals of algebra that will aid him in the solution of algebraic expressions involving polynomials, interest problems, and the use of logarithmic terms.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ
Reduce numerical and algebraic expressions containing operators and grouping symbols to their simplest form.

COND
Given an equation of the following form:

a. $5-[3\ 2+5(8-3)+6-6\ (8+3)-2]$

b. $4(3y-2)-6(7-5y)$

PL
Out of ten problems, seven must be correct.

2

OBJ
Evaluate an algebraic expression given a replacement value of the variable.

COND
Using the formula $3[2y-2y(y-2)+y]$ when $y=3$.

PL
Out of ten problems, seven must be correct.

3

OBJ
Determine if a given value is a solution to a first degree equation in one variable.

COND
Given a numerical value for y and an equation that can be reduced to the form $ay+b=cy+d$.

PL
Out of ten problems, seven must be correct.

4

OBJ
Solve a first degree equation in one variable.

COND
Given an equation that can be reduced to the form $ay+b=cy+d$.

PL
Out of ten problems, seven must be correct.

5

OBJ
Determine if an ordered pair is a solution to a first degree equation in two variables.

COND
Given an ordered pair (n,m) and an equation that can be reduced to the form $ax+b=cy+d$

PL
Out of ten problems, seven must be correct.

6

OBJ
Describe the rectangular coordinate system with x and y axes as a two-dimensional version of the number line.

COND
From recall.

PL
Description must include a labeled drawing of the axes, including a scale, positive-negative directions, and quadrants.

7

OBJ

Determine for a given coordinate system:

a. The coordinates.
b. The points on the graph.

COND

Given a coordinate system.

PL

100% correct.

8

OBJ

Graph first-degree equations in two variables.

COND

Given an equation that can be reduced to the form y=mx+b.

PL

100% correct.

9

OBJ

Find the slope and intercept of a line.

COND

Given an equation that can be reduced to the form y=mx+b.

PL

Out of ten problems, seven must be correct.

10

OBJ

Find the equation of a line.

COND

a. Given two points.
b. Given the slope and a point.

PL

Out of ten problems, seven must be correct.

11

OBJ

Solve a system of two equations in two unknowns using the following methods:

a. Graphically
b. Algebraically

COND

Given two different equations that can be reduced to the form y=mx+b.

PL

Out of ten problems, seven must be correct.

12

OBJ

Describe the meaning of the symbols $<$, $\leq$, $>$, and $\geq$.

COND

Given statements using the above relationships. For example:

a. $a < b$
b. $a-b \leq o$
c. a is greater than b

PL

Description must include the use of a number line to illustrate statements containing inequalities.

13

OBJ

Solve a first degree inequality in one variable.

COND

Given inequalities that can be reduced to the following forms:
ay+b*cy+d (where * is $<$, $\leq$, $\geq$ or $>$)

PL

Out of ten problems, seven must be correct.

14

OBJ

Find the absolute value of a variable.

COND

Given statements of the form:

a. $|y|$
b. $|y-a|$

PL

Out of ten problems, seven must be correct.

15

OBJ

Multiply and divide algebraic terms with exponents.

COND

Given an expression of the form:

$$\frac{(-a^2x^3y)^4\ (x\ y)^{-2}}{(ax^2y^3)^2}$$

PL

Out of ten problems, seven must be correct.

16

OBJ

Simplify an expression by collecting like terms.

COND

Given an expression of the form:

$$5x+6x^2y-3x+2xy+2x^2y+xy$$

PL

Out of ten problems, seven must be correct.

17

OBJ

a. Add, subtract, multiply, and divide fractions and rational expressions.

b. Find common denominator.

c. Reduce to lowest equivalent terms any given fraction or rational expression.

COND

Given expressions of the form:

a. $\frac{3}{4} + \frac{5}{6} - \frac{7}{8}$

b. $\frac{3}{4x} - \frac{2}{x2}$

c. $\frac{2}{x+3} \div \frac{5}{x}$

PL

Out of ten problems, seven must be correct.

18

OBJ

Solve a first degree equation in one variable, containing fractions.

COND

Given an equation that can be reduced to the form:

ay+b=cy±d (where a, b, c, d are fractions)

PL

Out of ten problems, seven must be correct.

19

OBJ

Simplify algebraic expressions containing radicals.

COND

Given statements of the form:

a. $\frac{3\sqrt{140}}{\sqrt{105}}$

b. $\frac{6}{\sqrt{5}+\sqrt{3}}$

c. $\sqrt{2} + \sqrt{8} - \sqrt{18}$

d. $\sqrt[5]{32}$

PL

Out of ten problems, seven must be correct.

20

OBJ

Replace radicals by rational exponents and simplify algebraic expressions.

COND

Given statements of the forms:

a. $\sqrt[6]{64^5}$

b. $\frac{(\sqrt[3]{a^2b})\ 2(\sqrt[3]{a^{-1}})}{\sqrt[3]{a^{-2}}}$

PL

Out of ten problems, seven must be correct.

21

OBJ

Solve equations containing radical expressions.

COND

Given equations of the form:

$$\sqrt{y+a} = b$$

PL

Out of ten problems, seven must be correct.

22

OBJ

Add, subtract, multiply, and divide polynomials.

COND

Given any two polynomials.

PL

Out of ten problems, seven must be correct.

23

OBJ

Find the product of two binomials using special products.

COND

Given statements of the form:

$$(ax+b)\ (cx+d)$$

PL

Out of ten problems, seven must be correct.

24

OBJ

Use factorization to simplify the expression.

COND

Given algebraic expressions of the form:

a. $8k^5m^2n^7 - 6k^3m^2n^3 - 12k^3m^4n^5$

b. $3x^2 - 5xy - 2y^2$

c. $\dfrac{8x^2+18xy-35y^2}{12x^3-31x^2y+20xy^2} \div \dfrac{4x^2+20xy+21y^2}{6x^2+xy-12y^2}$

PL

Out of ten problems, seven must be correct.

25

OBJ

Factor a fourth degree polynomial by reducing it to a second degree polynomial (e.g., x^4-16 can be reduced to y^2-16 where $y=x^2$).

COND

Given expressions of the form:

$$ax^4+bx^2+c$$

PL

Out of ten problems, seven must be correct.

26

OBJ

Solve a quadratic equation by:

a. Factoring
b. Quadratic formula

COND

Given equations of the form:

$$6x^2-4x-5=0$$

PL

Out of ten problems, seven must be correct.

27

OBJ

Determine the solution to algebraic expressions or equations.

COND

Using the graphic technique and given equations of the form:

$$x^3-6x^2+11x-6=0$$

PL

Out of ten problems, seven must be correct.

28

OBJ

Convert a number from decimal form to scientific notation, and from scientific notation to decimal form.

COND
Given:
a. 0.000704
b. 1.68×10^5

PL
100% correct.

29

OBJ
Use scientific notation to simplify multiplication and division.

COND
Given a problem such as:

$$\frac{(2.3400)(0.0043)}{4400}$$

PL
Out of ten problems, seven must be correct.

30

OBJ
Use log tables to find:
a. The logarithm to the base 10 of a given number.
b. The decimal form of a number when given its logarithm to the base 10.

COND
Given:
a. 0.0034 as your number.
b. 4.7818 as your logarithm.

PL
100% correct.

31

OBJ
Use logarithms to evaluate numeric expressions containing multiplication, division, powers, and roots.

COND
Given problems such as:
a. $(\sqrt[4]{17.6})^9$

b. $\frac{462 \times 0.00893}{0.1265 \times 0.00008265}$

PL
Out of ten problems, seven must be correct.

32

OBJ
Draw graphs on semi-log and log-log paper.

COND
Given a list of six ordered pairs.

PL
100% correct.

33

OBJ
Use the cross-product rule to solve a proportion.

COND
Given $\frac{a}{b} = \frac{c}{d}$ where one of a, b, c, or d is unknown.

PL
Out of ten problems, seven must be correct.

34

OBJ
Determine:
a. The constant of proportionality.
b. Additional pairs of numbers in the same variation.

COND
Given a pair of numbers belonging to a variation. An example of this problem is:

At constant temperature the pressure of a gas is inversely proportional to its volume. If at a given temperature the pressure is 15 ATM (atmospheres) when the volume is 200 liters, find the volume when the pressure is 30 ATM.

PL
Out of ten problems, seven must be correct.

35

OBJ

Determine the unknown in interest rates, time, or money.

COND

Given the two other quantities.

PL

100% correct.

Environmental Science 101
3 CREDITS

WATER QUALITY LABORATORY TECHNIQUES I

The purpose of this course is to assist the student in learning the use of basic laboratory equipment, instruments, and glassware. The analytical techniques for microbiological sampling and analysis will also be studied. The student will learn how to collect data, report and interpret results, and will learn asepsis and safety considerations in sampling and laboratory analysis. The student will also learn to recognize abnormal conditions and results and how to implement necessary changes.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ

Describe and demonstrate the procedures for the use of the following equipment and instruments:

a. Balances
b. Ovens
c. Desiccators
d. Furnaces
e. Hot plates
f. Hoods
g. Stills
h. pH meters
i. Spectrophotometers
j. Autoclaves

COND

Given an equipped laboratory.

PL

All equipment must be used correctly 90% of the time.

2

OBJ

Identify the proper volumetric glassware for a given analysis, and use it according to its graduation capacity or calibration markings:

a. Graduated cylinders.
b. Volumetric flasks.
c. Volumetric and measuring pipets.
d. Buret.

COND

Given one of the following references (see page 104, Appendix I).

Given an equipped laboratory.

PL

Appropriate glassware must be selected and used as stated in the above references 100% of the time.

3

OBJ

Describe and perform aseptically the listed techniques using the proper safety precautions:

a. Serial dilution.
b. Pouring agar plates.
c. Streaking agar slants and plates.
d. Making total counts.
e. Aseptic transfers with loop.
f. Preparing culture media.
g. Counting colonies.

COND

Given one of the following references (see page 104, Appendix I).

PL

Each technique must be performed successfully and free of outside contamination 90% of the time.

4

OBJ

Describe and demonstrate the procedure for the preparation of containers for sampling for bacteriological analysis, including fecal and total coliform and fecal streptococci.

COND

Given one of the following references (see page 104, Appendix I).

Given an equipped laboratory.

PL

90% of the sample containers must meet the specifications in one of the above references.

5

OBJ

Describe and demonstrate the procedure for collecting a sample for bacteriological analysis, including fecal and total coliform and fecal streptococci.

COND

Given the nature of the sample (grab or composite).

Given one of the following references (see page 104, Appendix I).

Given the location.

PL

90% of the samples must be taken in conformance with procedures in one of the above references, including:

a. Depth.
b. Sampling equipment needed.
c. Time of day.
d. Frequency.

6

OBJ

Describe and demonstrate the procedure for transporting a sample to the laboratory for bacteriological analysis, including fecal and total coliform and fecal streptococci.

COND

Given one of the following references (see page 104, Appendix I).

Given the interval from time of sampling to time of analysis, including:

a. Immediate (less than one hour).
b. Six hours.

PL

95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures described in one of the above references.

7

OBJ

Describe and demonstrate the procedure for storing bacteriological samples in the laboratory, including fecal and total coliform and fecal streptcocci.

COND

Given one of the following references (see page 104, Appendix I).

Given a maximum time interval of two hours over which the sample may be kept in the laboratory.

PL

95% of the samples stored must be suitable for analysis after the prescribed storage time.

8

OBJ

Select appropriate sample location in treatment plant or on water course for bacteriological samples, including fecal and total coliform and fecal streptococci.

COND

Given one of the following references:

a. Plant operational guide for plant in question.
b. (See page 104, Appendix I)

Given the nature of reason for the sample, including:

a. Determining efficiency of process.
b. Meeting a regulatory requirement.
c. Meeting a process requirement.

PL

Selection must include at least:

a. Location in plant.
b. Location in process unit or on stream.
c. Depth.

9

OBJ

Describe and perform the analysis for total and fecal coliform and fecal streptococci, including proper safety procedure.

COND

Given one of the following references (see page 104, Appendix I).

Given an equipped laboratory.

PL

90% of samples must fall within acceptable range as defined in one of the above references. Safety procedure must be followed 100% of the time.

10

OBJ

Describe and perform the data-handling skills for bacteriological indicators, including fecal and total coliform and fecal streptococci.

COND

Given one of the following references (see page 104, Appendix I).

PL

90% of results must be correct and 80% must conform to those in references.

11

OBJ

Recognize an abnormal condition in any of the analyses in any performance in objectives 4-10 and suggest and take the action necessary to correct the abnormal condition.

COND

Given one of the following references:

a. Laboratory control guide for laboratory in question.

b. (See page 104, Appendix I)

Given a laboratory logbook.

PL

80% of abnormal conditions must be spotted and corrected to meet performance levels in objectives 4-10.

English 101

3 CREDITS

COMMUNICATION SKILLS*

The purpose of this course is to assist the student in learning the basic concepts of English and how to apply these concepts in utilizing the language for clear and meaningful communications such as letter and report writing.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1
OBJ
Given a part of speech such as verb, describe its use in sentences and provide an appropriate example sentence using that part of speech.

2
OBJ
Define the following and give an example of each in a sentence:
a. Phrase
b. Clause

3
OBJ
Describe and give examples in sentences of the different types of clauses and phrases.

4
OBJ
Classify the structure of a sentence such as simple, compound, complex, and compound-complex.

5
OBJ
Given a list of sentences, identify the errors based on the following rules of grammar and mechanics, and correct the error. (A list will be given.)

6
OBJ
Given a series of sentences, correct for punctuation and spelling.

7
OBJ
Spell correctly any words given or written wrong.

8
OBJ
Use the dictionary to:
a. Find definitions.
b. Determine correct spelling of words.
c. Determine correct capitalization of words.
d. Determine the correct pronunciation of words.
e. Determine the correct usage of the right word in a sentence.

9
OBJ
Given a series of sentences:
a. Cross out any word or phrase not used in accordance with standard English. Insert the standard English equivalent.
b. Strike out each word used inappropriately and insert the correct or exact word.

10
OBJ
Using the procedures for good English, write a theme or essay on a topic of your choice.

*For this course, only objectives are given. The instructor should develop the conditions and performance levels.

55/56

Semester II

Chemistry 102
4 CREDITS

GENERAL CHEMISTRY II

The purpose of this course is to assist the student in learning the basic principles of chemistry and their application to the understanding, cause, analysis, and solution of environmental problems. Topics included are rates of reaction, equilibrium as applied to gaseous reactions, solubility, acids and bases, redox reactions, electrochemistry, descriptive chemistry of simple organic and inorganic compounds, and nuclear chemistry. Laboratory exercises will demonstrate the above and allow the student practical experience in obtaining quantitative results.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ

For a given reaction, such as: aA + bB → Products, explain what data you would take to determine:

a. The rate.
b. The order.
c. The activation energy.

COND

Given the balanced chemical reaction.

PL

Explanation must include the relationships between:

a. Rate and the concentration changes of reactants or products with time.
b. Order and the effect upon rate of changing the original concentrations of each reactant.
c. The change in rate with temperature and the activation energy.

2

OBJ

Describe the effect of each of the following upon the rate of a given reaction, including the role of activation energy:

a. Temperature.
b. Bond energy of reactants and products.
c. Entropy change.
d. Concentration of reactants.
e. Catalysts.

COND

Given a balanced chemical equation, a change in conditions, and an activation energy diagram.

PL

Discussion must include the relationships between:

a. Temperature, kinetic energy of molecules, bond strength, and activation energy.
b. The molecular geometry, the favorable arrangement of molecules for reaction, entropy, and reaction rate.
c. Concentration and the probability for a favorable collision in terms of energy and structure.
d. Catalysts and activation energy.

3

OBJ

Define the concept of steady state, and note the difference between a steady state and an equilibrium reaction.

COND

From recall.

PL

Discussion must include equations which show that an equilibrium reaction involves reversible reactions, but a steady state involves reactions such as A → B → C at rates which leave B at a constant concentration.

4

OBJ

Discuss in essay form and with chemical equations the nature of equilibrium as applied to chemical reactions, with emphasis on additional costs and potential pollution problems due to incomplete reactions.

COND

Given reversible reactions, including some with industrial or environmental effects.

PL

Discussion must include the nature of reversible reactions, and the effects of these incomplete reactions upon cost of a product and upon the need to remove unreacted chemicals from the environment.

5

OBJ

Given an equilibrium equation, predict the effect upon this equilibrium of changes in:

a. Temperature.
b. Concentration of reactants.
c. Pressure (for gases).
d. Catalyst.

COND

Given a balanced equilibrium equation and a set of conditions, including whether the reaction is exothermic or endothermic and the physical state of each of the reactants and products.

PL

80% correct.

6

OBJ

State the mathematical expression for an equilibrium equation when given the chemical equation, and solve that expression to calculate the equilibrium constant, the extent of reaction, or the concentration of any reactant or product.

COND

Given a balanced, reversible, chemical equation.

PL

Mathematical expression must include the statement that the concentration (or activity) of a solid is equal to unity. Computations must be correct 75% of the time.

7

OBJ

Define pH and calculate the pH of solutions of given concentrations of strong acids or bases.

COND

Given the concentration and formula and a statement that the acid is "strong." Define from recall.

PL

Definition must include the exponential or logarithmic relation between pH and molar hydrogen ion concentration. Calculations must be correct 75% of the time.

8

OBJ

Write the equation for the autoionization of water, define K_w, and state the numerical value of K_w.

COND

From recall.

PL

Definition must be a mathematical expression for K_w.

9

OBJ

Calculate the pH of known concentrations of weak acids or bases.

COND

Given a value for the ionization constants.

PL

75% correct.

10

OBJ

Describe how acid-base indicators work, using a titration curve of pH vs. volume

of titrant to illustrate the concept.

COND
Given a titration curve.

PL
Description must include the acid-base nature of the indicator and indicate the pH range of a useful indicator shown on the curve.

11

OBJ
Define a buffer solution, give directions for the preparation of a buffer, and describe how a buffer resists change in pH when:
a. An acid is added.
b. A base is added.

COND
From recall.

PL
Description must use chemical and mathematical expressions for the equilibrium reaction to show the effect of increasing the concentration of any one species in the equilibrium. (See OBJ 5b.)

12

OBJ
Calculate the pH of specific buffer solutions, including buffers from H_3PO_4 and its salts or from carbonate and bicarbonate salts, and prepare a buffer of a given pH.

COND
Given:
a. A value of the ionization constant(s) and a desired pH.
b. Acids and bases or solutions of known concentration and suitable glassware.

PL
Calculations must be correct 75% of the time, and the solution prepared must be correct within ± 0.2 pH units.

13

OBJ
Define solubility and solubility product constant, and use the K_{sp} to calculate the solubility of a slightly soluble salt such as AgCl in:
a. Water.
b. A solution containing a known concentration of a common ion, e.g., 0.1M Nacl.

COND
Given a salt, the value for K_{sp}, and any needed concentrations.

PL
75% correct.

14

OBJ
Describe solvent extraction in terms of equilibria.

COND
From recall.

PL
Description must include:
a. That the distribution coefficient is an equilibrium constant.
b. That diffusion across the interface is reversible.
c. The effect of shaking or stirring upon the rate of establishment of equilibrium.

15

OBJ
Illustrate the electron transfer in oxidation-reduction (redox) equations and balance these equations using the ion-electron method.

COND
Given a completed oxidation-reduction equation and the periodic chart.

PL
Illustration must separate the overall equation into the oxidation step and the reduction step, showing the number of electrons required to balance the

charges. Add these partial "ion-electron" or "half" equations to balance the coupled redox equation.

16

OBJ

Describe the operation of a simple battery composed of two standard half-cells.

COND

Given two reactants and a table of half-cell (oxidation or reduction) potentials.

PL

Description must include:

a. The voltage produced.

b. The direction of flow of electrons in the external circuit.

c. The purpose of a salt-bridge or its equivalent.

d. The oxidation or reduction equation which takes place at each electrode.

e. A diagram of a completed battery.

17

OBJ

Use Faraday's laws to calculate the weight, number of equivalents, and concentration change for both electrodes and solution during an electrolysis or while a cell is generating current.

COND

Given the redox reaction, concentrations of solutions, current flow, and the periodic chart.

PL

75% correct.

18

OBJ

State the mathematical expression which shows how the voltage of the hydrogen half-cell depends on concentration, and describe the potential application of this as a "pH electrode."

COND

From recall.

PL

Description must include the concept that voltage can be used as a measure of H^+ concentration, thereby giving a convenient measure of pH electronically.

19

OBJ

Identify, name, or draw structural formulae for the following organic compounds:

a. Aliphatic hydrocarbons with up to 10 carbon atoms.

b. Aromatic compounds, including the nature of the bonding which differentiates aromatic from aliphatic compounds.

c. Alcohols.

d. Acids.

e. Esters.

f. Ethers.

g. Aldehydes.

h. Ketones.

i. Amines.

j. Amino acids.

COND

From recall, given the name or formula and the periodic chart.

PL

80% correct.

20

OBJ

Identify or draw structural formulae for:

a. Structural isomers.

b. Geometric isomers (cis-trans).

c. Optical isomers.

COND

Given the name.

PL

80% correct.

21

OBJ

Describe the nature of each of the

following chemical, industrial, or biological processes:

a. The carbon cycle.
b. The nitrogen cycle.
c. Industrial production of NH_3.
d. Production of iron.
e. Production of copper.
f. Burning of fuels, such as gasoline or coal.
g. Production and use of H_2SO_4.
h. Corrosion of metals.
i. Aerobic and anaerobic reactions.

COND
From recall, given the name of the process and the periodic chart.

PL
Description must include pertinent chemical equations, note any important equilibria or conditions, and evaluate the economic and environmental impact of the process.

22

OBJ
Define the following with respect to nuclear energy:

a. Radioactivity.
b. Contamination.
c. Ionizing radiation.
d. Fallout.

COND
From recall.

PL
90% correct.

23

OBJ
Complete and balance nuclear equations illustrating:

a. Alpha decay.
b. Beta decay.
c. Gamma emission.
d. (n, γ) reactions.

COND
Given the periodic chart and the equation with only one reactant or product missing.

PL
80% correct, showing the symbol, atomic number, and atomic weight of the unknown species.

24

OBJ
Define the concept of half-life and describe the use of half-life in dating the age of a substance.

COND
From recall, given the half-life of an isotope for the description.

PL
Description must include the reasons a "zero" time can be estimated and a sample estimation of age by dating.

25

OBJ
Describe the processes of fission and fusion as related to the nucleus.

COND
From recall, or given an equation.

PL
Description must include the requirements for fission and fusion of the nucleus. These must be related to nuclear weapons, to potential and present energy production, and to environmental problems.

26

OBJ
Demonstrate the use of the following equipment:

a. Spectronic 20 spectrophotometer.
b. pH meter.
c. Separatory funnel.
d. Centrifuge.
e. Geiger-Müller counters.
f. Radioisotope generators.
g. Distillation apparatus.

COND
Given a stocked laboratory and the necessary chemicals and an instruction sheet.

PL

Each item must be used correctly 80% of the time and safely 100% of the time.

27

OBJ

Demonstrate the following laboratory techniques:

a. Determine the rate of a reaction and show the effect upon that rate of:

1. temperature.
2. concentration of reactants.
3. a catalyst.

b. Demonstrate the effect upon an equilibrium reaction of:

1. temperature.
2. concentration of reactants.

c. Determine the extent of ionization of a weak acid or base and calculate K_i.

d. Determine the solubility of a slightly soluble solid and calculate K_{sp}.

e. Prepare a buffer solution of predetermined pH to within ± 0.2 pH unit.

f. Perform a pH titration, plot the data, and explain the results in terms of the common ion effect and buffered solutions.

g. Perform a liquid-liquid extraction and calculate K_d.

h. Perform a redox titration and calculate the equivalent weight of an oxidizing or reducing agent.

i. Use molecular models to demonstrate the structures of organic compounds.

j. Determine the half-life of barium-137m.

k. Demonstrate the use of absorbers and distance (the inverse square law) to reduce radiation exposure.

l. Perform a fractional distillation of a mixture of organic compounds.

COND

Given an equipped laboratory, the necessary chemicals, and an instruction sheet.

PL

Each experiment must be done correctly 80% of the time and safely 100% of the time.

Mathematics 102
3 CREDITS

STATISTICAL ANALYSIS

The purpose of this course is to assist in learning the fundamentals of elementary statistics and some of its important applications. Topics included are the organization and presentation of numerical data, measures of central tendency and dispersion, probability, the binomial and normal distributions, random sampling, hypothesis testing, confidence limits, t-testing, Chi-square testing, regression, and correlation.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ
Define and illustrate:
a. Statistics (the subject matter).
b. Raw score.
c. Distribution.
d. Population.
e. Sample.
f. Random sample.
g. Parameter.
h. Statistic.
i. Measure of central tendency.
j. Measure of variation.

COND
From recall.

PL
75% correct.

2

OBJ
Using the appropriate formulae, calculate the mean, geometric mean, median, mode, range, variance, and standard deviation for a given distribution.

COND
From recall.

PL
Recall of formulae must be 100% correct. Calculations must be correct 75% of the time.

3

OBJ
Use a calculator to find the mean, variance, and standard deviation for larger distributions.

COND
Given the short-cut forms of the formulae for use with a standard desk calculator.

PL
Calculations must be correct 75% of the time.

4

OBJ
Calculate and interpret the "z-score" for a particular raw score from a distribution.

COND
From recall.

PL
Formula and interpretation must be 100% correct. Calculations must be correct 75% of the time.

5

OBJ
Interpret the percentile rank of a given raw score in a given distribution.

COND
From recall.

PL
75% correct.

6

OBJ
Define and illustrate:
a. Discrete random variable.
b. Continuous random variable.
c. Frequency.

d. Frequency table.
e. Class interval.
f. Class boundary.
g. Histogram.

COND
From recall.

PL
75% correct.

7

OBJ
Organize a given collection of data and present it in the form of a frequency table and for histogram.

COND
Given a distribution for which a frequency table or histogram is appropriate.

PL
75% correct.

8

OBJ
State and apply the definition of "probability of an event" in doing elementary probability problems.

COND
From recall and familiarity with basic properties of elementary probability.

PL
75% correct.

9

OBJ
Recognize a binomial random variable and be familiar with the characteristics of its distribution.

COND
From recall.

PL
75% correct.

10

OBJ
Describe the use of Pascal's triangle and its construction.

COND
Given a binomial random variable and the need of the probability of S successes in n trials.

PL
75% correct.

11

OBJ
Calculate binomial probabilities.

COND
Given Pascal's triangle and the binomial probability formula, the number of trials, the desired number of successes, and the probability of success on each trial.

PL
75% correct.

12

OBJ
Describe the properties of a normal distribution curve.

COND
From recall.

PL
75% correct.

13

OBJ
State the proportion of a normal distribution (to the nearest whole per cent) which lies between $-\sigma$ and σ, -2σ and 2σ, and -3σ and 3σ units (respectively) of its mean.

COND
Given the mean and σ (standard deviation) of the normal distribution.

PL
75% correct.

14

OBJ
Interpret and apply the tables of the standard normal distribution to find normal probabilities (area S under the standard normal curve).

COND
Given a standard normal random variable, its mean, and standard deviation.

PL
75% correct.

15

OBJ
Approximate binomial probabilities (where appropriate) by using the normal distribution and standard normal tables.

COND
Given the description of the binomial distribution, including its mean and standard deviation.

PL
75% correct.

16

OBJ
Define and illustrate:
a. Null hypothesis.
b. Alternate hypothesis.
c. Significance level.
d. Type I error.
e. Type II level.
f. Decision rule.
g. One-tail test.
h. Two-tail test.
i. Critical region.

COND
From recall.

PL
75% correct.

17

OBJ
Set up a test of hypothesis by applying the following steps:
a. State the null and alternate hypotheses.
b. State the significance level.
c. State the critical region.
d. Perform the computation of the test statistic.
e. Make the appropriate conclusion(s) based on the above steps.

COND
Given the statistical information in the problem at hand and the appropriate statistical tables.

PL
75% correct.

18

OBJ
In the case of a binomial random variable, perform tests of hypotheses involving proportions (for both one- and two-population discussions).

COND
Given the necessary information on the binomial distribution and the standard normal tables (if appropriate).

PL
75% correct.

19

OBJ
Explain the central limit theorem.

COND
From recall.

PL
75% correct.

20

OBJ
State and explain the relationships between the population mean and the mean of the distribution of sample mean, and between the population standard deviation and the standard deviation of the distribution of sample means.

COND
From recall.

PL
75% correct.

21

OBJ
In the case of large-sample hypothesis testing, perform tests of hypotheses concerning the population mean(s) (for both one- and two-population situations).

COND
Given the characteristics of the sample(s) involved and the standard normal tables.

PL
75% correct.

22

OBJ
Explain when the Student's t-distribution is used in hypothesis testing concerning population mean(s), and properly use the t-tables.

COND
Given the Student t-tables.

PL
100% correct.

23

OBJ
In the case of small-sample hypothesis testing, perform tests of hypotheses concerning the population mean(s) (for both one- and two-population situations).

COND
Given the characteristics of the sample(s) involved and the t-tables.

PL
75% correct.

24

OBJ
Define and illustrate:
a. Point estimate.
b. Interval estimate.
c. Confidence interval.

COND
From recall.

PL
75% correct.

25

OBJ
State the characteristics of the Chi-square distribution, and use the Chi-square tables.

COND
From recall, given the Chi-square tables.

PL
100% correct.

26

OBJ
Identify the conditions and limitations under which it is appropriate to use the Chi-square testing procedure for testing for independence between variables.

COND
From recall.

PL
75% correct.

27

OBJ
Perform the Chi-square test for independence between two variables and interpret the results of the test.

COND
Given the "observed" scores (frequencies) and the Chi-square tables.

PL
75% correct.

28

OBJ
Define:
a. Correlation.
b. Positive correlation.
c. Negative correlation.
d. Zero correlation.
e. Perfect correlation.
f. Scattergram.
g. Least squares fit.
h. Best-fit.

COND
From recall.

PL
75% correct.

29

OBJ
Calculate the correlation coefficient between two sets of measurements, and test the significance of the result.

COND
Given the two sets of measurements (data) in paired form and the t-tables.

PL
75% correct.

30

OBJ
Apply the least squares method of best-fit, and do the necessary computations to produce the equation of best-fit (for at least the linear case).

COND
Given the necessary data and calculator (if needed).

PL
75% correct.

31

OBJ
Use the best-fit equation for prediction purposes.

COND
Given the equation of best-fit and the values of the independent variable for which prediction is requested.

PL
75% correct.

Environmental Science 102

3 CREDITS

WATER QUALITY LABORATORY TECHNIQUES II

The purpose of this course is to assist the student in learning the analytical techniques for the list of analyses below. The procedures for sampling, analyzing, interpreting, and reporting results will be discussed. Safety in the laboratory will be covered. The student will learn how to recognize abnormal results in procedures and how to remedy the situation.

This course is concerned with the following analyses:

1. BOD_5.
2. DO.
3. COD.
4. Total dissolved solids.
5. Total suspended solids.
6. Total volatile solids.
7. Total solids.
8. Chlorine.
9. pH.
10. Organic nitrogen.
11. Kjeldahl nitrogen.
12. Ammonia.
13. Nitrate.
14. Nitrite.
15. Orthophosphate.
16. Total organic carbon.
17. Total phosphorous.
18. Acidity.
19. Alkalinity (liquid and sludge).
20. Hardness.
21. Total acidity (sludge).
22. Volatile acids.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ

Describe and demonstrate the procedure for the preparation of containers for sampling for any of the listed analyses.

COND

Given one of the following references (see page 104, Appendix I).

Given an equipped laboratory.

PL

90% of the sample containers must meet the specifications in one of the above references.

2

OBJ

Describe and demonstrate the procedure for collecting a sample for any of the listed analyses.

COND

Given the nature of the sample (grab or composite).

Given one of the following references (see page 104, Appendix I).

Given the location.

PL

90% of the samples taken must be taken in conformance with procedures in one of the above references, including:

a. Depth.
b. Sampling equipment needed.
c. Time of day.
d. Frequency.

3

OBJ

Describe and demonstrate the procedure for transporting a sample to the laboratory for any of the listed analyses.

COND

Given one of the following references (see page 104, Appendix I).

Given the interval from time of sample to time of analysis, including:

a. Immediate (less than 30 minutes)
b. Four hours.
c. Twelve hours.
d. One day.

e. Two days.
f. One week.

PL
95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures described in one of the above references.

4

OBJ
Describe and demonstrate the procedure for storing samples in the laboratory for any of the listed analyses.

COND
Given one of the following references (see page 104, Appendix I).
Given the time interval over which the sample must be kept in the laboratory, including:
a. Six hours.
b. One day.
c. One week.
d. One month.
e. Six months.

PL
95% of the samples stored must be suitable for analysis after the prescribed storage time.

5

OBJ
Select appropriate sample location in plant or on watercourse for any of the listed analyses.

COND
Given one of the following references:
a. Plant operational guide for plant in question.
b. (See page 104, Appendix I).
Given the nature or reason for the sample, including:
a. Determining efficiency of process.
b. Meeting a regulatory requirement.
c. Meeting a process requirement

PL
Selection must include:
a. Location in plant.
b. Location in process unit or on stream.
c. Depth.

6

OBJ
Describe and perform the analysis for any of the listed analyses, including proper safety procedure.

COND
Given one of the following references (see page 104, Appendix I).
Given an equipped laboratory.

PL
90% of samples must fall within acceptable range as defined in one of the above references. Safety procedures must be followed 100% of the time.

7

OBJ
Describe and perform the procedure for the chemical analyses listed, including reporting and interpreting the results.

COND
Given one of the following references (see page 104, Appendix I).
Given charts, nomographs, standard curves, calculator.

PL
90% of results must be correct and 80% of interpretation must conform to those in references.

8

OBJ
Recognize an abnormal condition in any of the analyses in any performance in objectives 1-7, and suggest and take the action necessary to correct the abnormal condition.

COND
Given one of the following references:
a. Laboratory control guide for plant in question.
b. (See page 105, Appendix II).

Given charts, nomographs, standard curves, calculator, laboratory logbooks.	PL 80% of abnormal conditions must be spotted and corrected to meet performance level in objectives 1-7.

Environmental Science 103

3 CREDITS

WATER QUALITY CONTROL PROCESSES

The purpose of this course is to assist the student in learning to name and recognize the unit processes found in various types of municipal and industrial wastewater treatment plants in order to communicate with plant operating personnel. He will learn why the unit processes are sequenced as they are and what change in the wastestream is brought about by each unit process and sequence of unit processes. The effects of the wastewater characteristics on the treatment process and receiving stream will be discussed. Procedures will be given for determining the type of sample to be taken to characterize the wastestream for process control or regulatory purposes. The student will be able to prepare flow diagrams of unit process, as that would be needed to accomplish given processes or regulatory requirements.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ

Name the unit process(es) and describe the physical, chemical, and biological principles involved in its functioning that bring about a change in a characteristic of a wastestream.

COND

Given one or more wastewater characteristics.

PL

Description must include all those combinations of units that will bring about a change in the wastestream, as selected from the unit processes in Appendix III, page 107.

2

OBJ

Select from a list of tests those that will evaluate whether a unit process meets the process control requirements.

COND

Given a list of analyses; a description of where, when, and how the sample was taken from unit processes or combination of unit processes listed in Appendix III, page 107; and a reference document relating analyses with process control requirements.

PL

100% correct.

3

OBJ

Describe the effect the given wastewater characteristic(s) will have on a treatment process or receiving stream.

COND

Given a list of wastewater characteristics and a list of various treatment processes and receiving streams (including intermittent stream, small stream, large river, lake, impoundment, estuary, ocean).

PL

For any given situation at least 80% of the physical, chemical, or biological effects must be included.

4

OBJ

Construct flow diagrams containing the most probable unit processes needed to accomplish given treatment requirements.

COND

Given a list of the influent wastewater characteristics, the process control or regulatory requirements, and performance capabilities of unit processes.

PL

Description must include:

a. All major unit processes. (No extra unit processes may be included.) The following must be included, where applicable:

1. Primary treatment (three types).

2. Secondary treatment (trickling filter, three types of activated sludge, lagoons).

3. Tertiary treatment (six types).

Acceptable unit processes ar listed in Appendix III, page 107.

b. All flow directions and all additions and withdrawals.

75/76

Summer

Environmental Science 104
3 CREDITS

WATER QUALITY LABORATORY EXPERIENCE

The purpose of this course is to give the student an actual work experience in a laboratory concerned with wastewater analyses. The laboratory must be associated with a treatment plant. The student will prepare sample containers and collect, transport, analyze, and prepare reports on the analyses for the following tests. (If at all possible, all of the analyses performed in Environmental Science 101 and 102 should be included in this work experience.)

1. Fecal coliform.
2. Total coliform.
3. Fecal streptococci.
4. Nitrogen forms.
5. Phosphorous forms.
6. Acidity.
7. Alkalinity.
8. BOD.
9. COD.
10. Solid forms.
11. Chlorine.

OPTIONAL

The student will gain experience in communicating with visitors to the laboratory by discussing the reasons for treatment plants, the unit processes in a treatment plant, and how each of these changes the characteristics of the waste as it flows through the plant. The student will discuss the role of the laboratory in process control and making measurements to verify that the plant is meeting regulatory requirements.

WHEN YOU COMPLETE THIS SUMMER PROGRAM, YOU WILL HAVE MADE:

1

OBJ

All of the analyses performed in Environmental Science 101 and Environmental Science 102.

2

OBJ

An oral presentation to staff and visitors to the laboratory.

COND

Given:

a. References and class notes from first year of study.
b. Level of knowledge of visitors.
c. Duration of presentation.
d. Time and depth of coverage expected in presentation.

PL

Discussion must include the following points:

a. Characteristics of wastestreams.
b. How treatment process changes waste characteristic.
c. Flow diagrams of treatment processes.
d. Role of laboratory in process control and meeting regulatory requirements.
e. Effects of waste discharges on the environment.

79/80

Semester III

Environmental Science 201
3 CREDITS

WATER QUALITY LABORATORY TECHNIQUES III

The purpose of this course is to assist the student in learning the analytical techniques for the determination of the list of analyses below. The procedures for sampling, analyzing, interpreting, and reporting results will be discussed. Safety in the laboratory will be covered. The student will learn how to recognize abnormal results in procedures and how to remedy the situation. This course is concerned with the following analyses:

1. Cyanide.
2. Color.
3. Fluoride.
4. Sulfide.
5. Per cent H_2S (gas).
6. Specific conductance.
7. Temperature.
8. Turbidity.
9. Total alpha.
10. Total beta.
11. Radium.
12. SVI-SDI.
13. Per cent CH_4 (gas).
14. Sludge age.
15. Sludge filterability.
16. Sulfate.
17. Sulfite.
18. Bromide.
19. Chloride.
20. Per cent CO_2 (gas).
21. Grit analysis.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ

Describe and demonstrate the procedure for the preparation of containers for sampling for any of the listed analyses.

COND

Given one of the following references (see page 104, Appendix I).

Given an equipped laboratory.

PL

90% of the sample containers must meet the specifications in one of the above references.

2

OBJ

Describe and demonstrate the procedure for collecting a sample for any of the listed analyses.

COND

Given the nature of the sample (grab or composite).

Given one of the following references (see page 104, Appendix I).

Given the location.

PL

90% of the samples collected must be taken in conformance with procedures in one of the above references, including:

a. Depth.
b. Sampling equipment needed.
c. Time of day.
d. Frequency.

3

OBJ

Describe and demonstrate the procedure for transporting a sample to the laboratory for any of the analyses.

COND

Given one of the following references (see page 104, Appendix I).

Given the time interval from time of sample to time of analysis, including:

a. Immediate (less than 30 minutes).
b. Four hours.
c. Twelve hours.
d. One day.
e. Two days.
f. One week.

PL

95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures described in one of the above references.

4

OBJ

Describe and demonstrate the procedure for storing samples in the laboratory for any of the analyses.

COND

Given one of the following references (see page 104, Appendix I).

Given the time interval over which the sample must be kept in the laboratory, including:

a. Six hours.
b. One day.
c. One week.
d. One month.
e. Six months.

PL

95% of the samples stored must be suitable for analysis after the prescribed storage time.

5

OBJ

Select appropriate sample location in plant or on watercourse for any of the analyses.

COND

Given one of the following references:

a. Plant operational guide for plant in question.
b. (See page 104, Appendix I.)

Given the nature of or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting a regulatory requirement.
c. Meeting a process requirement.

PL

Selection must include:

a. Location in plant.
b. Location in process unit or on stream.
c. Depth.

6

OBJ

Describe and perform the analysis for for any of the analyses in the list, including proper safety procedures.

COND

Given one of the following references (see page 104, Appendix I).

Given an equipped laboratory.

PL

90% of the samples must fall within acceptable range as defined in one of the above references. Safety procedures must be followed 100% of the time.

7

OBJ

Describe and perform the procedure for analyzing, reporting, and interpreting the results from a laboratory analysis for any of the analyses.

COND

Given one of the following references (see page 104, Appendix I).

Given charts, nomographs, standard curves, calculator.

PL

90% of results must be correct and 80% of interpretation must conform to those in references.

8

OBJ

Recognize an abnormal condition in any of the analyses in any performance in objectives 1-7 and suggest and take the action necessary to correct the abnormal condition.

COND

Given one of the following references:

a. Laboratory control operational guide for plant in question.

b. (See page 104, Appendix I.)

Given charts, nomographs, standard curves, calculator, laboratory logbooks.

PL

80% of abnormal conditions must be spotted and corrected to meet performance level in objectives 1-7.

Chemistry 201
4 CREDITS

INSTRUMENTATION

The purpose of this course is to assist the student in applying the basic principles of chemistry to the qualitative identification and quantitative determination of environmental constituents and pollutants. The fundamental attention to good analytical technique will be stressed. Proper concern will be maintained for the fundamentals of analysis, such as sampling, standardization, and calibration. The main emphasis will be placed on the development of a working knowledge of analytical instruments and their use in environmental analysis.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ
Illustrate the meaning of precision and accuracy by:
a. Listing a set of pH readings that are precise.
b. Listing a set of pH data that shows accuracy.
c. Stating how the standard deviation is related to precision.

COND
From recall.

PL
80% correct.

2

OBJ
Explain what types of error occur in experimental measurements, and show how these types of error are treated in reporting experimental results.

COND
From recall.

PL
80% correct.

3

OBJ
Calibrate pipets and burets.

COND
Given a stocked laboratory, including an analytical balance.

PL
Calibration must be within ± 1% of the correct value.

4

OBJ
Describe the purpose of the following electrodes and how they function:
a. Calomel electrode.
b. Hydrogen electrode.
c. Dissolved oxygen electrode.
d. Fluoride electrode.

COND
Given diagrams showing the parts of the electrode and a list of the chemicals or materials used in the electrode.

PL
In the discussion 80% of the substances on the list must be properly identified as to purpose.

5

OBJ
Explain how current is carried in:
a. A solution.
b. A wire.
c. A vacuum tube.

COND
From recall.

PL
Explanation must indicate the similarities and differences in conductivity between the three systems.

6

OBJ
State the relationship between voltage,

resistance, and current; and measure voltage, resistance, and current in checking electrical circuits.

COND

State from recall. Measure when given a circuit and appropriate test equipment.

PL

Measurements must be within ± 10% of a known test circuit.

7

OBJ

Define regions of the electromagnetic spectrum in terms of frequency and wavelength, and describe the type of atomic or molecular behavior associated with each region.

COND

Given a list or table of wavelengths or frequencies.

PL

80% correct. Description must include the correlation between:

a. Rotations and vibrations for the infrared spectrum.

b. Electronic transitions for the visible, ultraviolet, and x-ray spectra.

8

OBJ

State Beer's Law and use this law in quantitative calculations of concentrations of compounds or ions.

COND

From recall. Given standardization data and the absorbance for an unknown.

PL

80% correct.

9

OBJ

For each of the following techniques or instruments, describe the process involved, demonstrate the use of the instrument or technique by performing at least one analysis, and do preventive maintenance on each.

a. Amperometric titration.

b. Conductivity apparatus.

c. Turbidimeter.

d. pH meter.

e. Specific ion meter.

f. Continuous monitors.

g. Ultraviolet-visible spectrometer, such as Spectronic 20.

h. Atomic absorption spectrometer.

i. Flame emission spectrometer.

j. Autoanalyzer I.

k. Gas chromatograph, including its use in:

1. qualitative analysis.

2. quantitative analysis.

3. separation of a mixture.

l. Organic carbon analyzer.

m. Infrared spectrometer.

n. Thin layer chromatography.

o. Liquid scintillation counter.

p. Proportional counter.

COND

Given operating instructions, the instrument, suitable standard and test solutions, and a schematic diagram of the instrument.

PL

Description must include the atomic or molecular behavior involved in the measurement.

Analysis must be performed to within ± 2 times the limits of the instrument for that measurement in 70% of tests on each instrument, and must include calibration or standardization.

Preventive maintenance must include:

a. Keeping instrument parts clean, dry, and free of contaminants.

b. Minor electrical adjustments.

c. Calling in experts or shipping the instrument to the factory for complex repairs.

10

OBJ

Demonstrate the ability to operate and do preventive maintenance on the following:

a. Oven.

b. Desiccator.

c. Distillation apparatus.

d. Vacuum pump.
e. Distillation and reflux apparatus.
f. Extraction equipment.
g. Digestion equipment.
h. Controlled temperature bath.

COND

Given the instrument, an equipped labatory, and any instrument manuals available.

PL

Operation and maintenance must include checking for dangerous glass or electrical connections, standardizing temperature controls, and checking for low or impure oil or bath levels.

Environmental Science 203
3 CREDITS

WATER QUALITY LABORATORY MANAGEMENT I

The purpose of this course is to assist the student in preparing an inventory of the supplies and equipment used for the laboratory control procedures. The student will learn how to use chemical catalogues for ordering supplies and equipment. The student will learn to prepare daily, monthly, and annual reports for laboratory and regulatory purposes. The student will learn to make presentations on the laboratory operations and procedures to operators in the plant and visitors to the plant who have no technical background. The student will learn instructional techniques to use for instructing new trainees who will work under his direction.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ

Develop and maintain inventory systems for laboratory equipment and supplies.

COND

Given an equipped laboratory with equipment and supplies.

PL

Inventory systems must include the following equipment and supplies (see page 108, Appendix IV).

2

OBJ

Prepare order forms for equipment and supplies.

COND

Given forms from industrial laboratory, municipal laboratory, and regulator agency laboratory; catalogues from at least ten supply houses and equipment suppliers; and an inventory list of needed equipment and supplies.

PL

Order forms must include the following equipment and supplies (see page 108, Appendix IV).

3

OBJ

Prepare daily, monthly, and annual reports for laboratory operations and regulatory purposes.

COND

Given report forms relating to laboratory operations and for regulatory agencies, plant specifications, effluent standards, regulatory requirements, receiving water standards, plant design specifications, inventory data, monitoring requirements, laboratory analysis results, laboratory daily logs, flow data, chemical usage, purchasing records, personnel records, consumable material inventories, operator log sheets, safety records.

PL

Reports must include the following: New equipment costs, equipment replacement costs, equipment repair costs, equipment utilization, supply costs (general, analytical, chemical, process chemical costs and usage), tests performed, cost per analysis, work schedules, research performed and resulting savings or improved operations, plant efficiencies, comparisons with plant loadings, process changes suggested, articles and presentations, safety training, personnel advancement.

4

OBJ

Demonstrate instructional techniques in training new laboratory personnel.

COND

Laboratory equipped with supplies and equipment, audiovisual equipment and

instructional materials, reference book on available instructional materials.

PL

Instructional approach used must conform to a proven technique (e.g., some reference such as "Selecting Instructional Media and Instructional Systems"*).

Trainee must achieve objectives of instructional sequence at a prescribed level and in a prescribed time under direction of instructor.

*Development and Exchange of Instructional Resources in Water Quality Control Programs. Vol. IV. Environmental Protection Agency and Charles County Community College. 1974.

English 102
2 CREDITS

TECHNICAL REPORT WRITING*

The purpose of this course is to assist the student in learning the principles and application of business and technical writing.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1
OBJ
Write general and specific types of business communications, including order letters, inquiries and replies, intra-office memos, recommendations, and general business correspondence.

2
OBJ
Examine and interpret data from a technical paper, a report, a research paper, a case history, and a project proposal.

3
OBJ
Write a report, project proposal, and case history.

4
OBJ
Describe the methods for planning, organizing, writing, and summarizing a report.

5
OBJ
Distinguish between connotations and euphemisms.

*For this course, only objectives are given. The instructor should develop the conditions and performance levels.

93/94

Semester IV

Environmental Science 202
3 CREDITS

WATER QUALITY LABORATORY TECHNIQUES IV

The purpose of this course is to assist the student in learning the analytical techniques for the determination of the list of analyses below. The procedures for sampling, analyzing, interpreting, and reporting results will be discussed. Safety in the laboratory will be covered. The student will learn how to recognize abnormal results in procedures and how to remedy the situation.

This course is concerned with the following analyses of which many (noted by an asterisk) can be analyzed with the Atomic Absorption Spectrophotometer if available:

1. Arsenic*
2. Aluminum*
3. Boron
4. Chromium (VI)
5. Mercury (flameless)*
6. Selenium*
7. Lead*
8. Antimony*
9. Barium*
10. Beryllium*
11. Cadmium*
12. Calcium*
13. Chromium total*
14. Cobalt*
15. Copper*
16. Iron*
17. Magnesium*
18. Manganese*
19. Molydbenum*
20. Nickel*
21. Potassium (or flame emission)*
22. Silver*
23. Sodium (or flame emission)*
24. Thallium*
25. Tin*
26. Titanium*
27. Vanadium*
28. Zinc*
29. Oil and grease
30. Phenols
31. Surfactants
32. Chlorinated organic compounds
33. Organo-phosphorus
34. Pesticides
35. Algicides
36. Benzidine

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ
Describe and demonstrate the procedure for the preparation of containers for sampling for any of the listed analyses.

COND
Given one of the following references (see page 104, Appendix I).
Given an equipped laboratory.

PL
90% of the sample containers must meet the specifications in one of the above references.

2

OBJ
Describe and demonstrate the procedure for collecting a sample for any of the analyses.

COND
Given the nature of the sample (grab or composite).
Given one of the following references (see page 104, Appendix I).
Given the location.

PL
90% of the samples must be taken in conformance with procedures in one of the above references, including:

a. Depth.
b. Sampling equipment needed.
c. Time of day.
d. Frequency.

3

OBJ

Describe and demonstrate the procedure for transporting a sample to the laboratory for any of the analyses.

COND

Given one of the following references (see page 104, Appendix I).

Given the time interval from time of sample to time of analysis, including:

a. Immediate (less than 30 minutes).
b. Four hours.
c. Twelve hours.
d. One day.
e. Two days.
f. One week.

PL

95% of the samples arriving at the laboratory must be suitable for analysis in conformance with procedures described in one of the above references.

4

OBJ

Describe and demonstrate the procedure for storing samples in the laboratory for any of the analyses.

COND

Given one of the following references (see page 104, Appendix I).

Given the time interval over which the sample must be kept in the laboratory, including:

a. Six hours.
b. One day.
c. One week.
d. One month.
e. Six months.

PL

95% of the samples stored must be suitable for analysis after the prescribed storage time.

5

OBJ

Select appropriate sample location in plant or on watercourse for any of the analyses.

COND

Given one of the following references:

a. Plant operational guide for plant in question.
b. (See page 104, Appendix I.)

Given the nature or reason for the sample, including:

a. Determining efficiency of process.
b. Meeting a regulatory requirement.
c. Meeting a process requirement.

PL

Selection must include:

a. Location in plant.
b. Location in process unit or on stream.
c. Depth.

6

OBJ

Describe and perform the analysis for any of the analyses in the list, including proper safety procedures.

COND

Given one of the following references (see page 104, Appendix I).

Given an equipped laboratory.

PL

90% of samples must fall within acceptable range as defined in one of the above references. Safety procedures must be followed 100% of the time.

7

OBJ

Describe and perform the procedure for analyzing, reporting, and interpreting the results from a laboratory analysis for any of the analyses.

COND

Given one of the following references (see page 105, Appendix II).

Given charts, nomographs, standard curves, calculator.

PL

90% of results must be correct and 80%

of interpretation must conform to those in references.

8

OBJ

Recognize an abnormal condition in any of the analyses in any performance in objectives 1-7, and suggest and take the action necessary to correct the abnormal condition.

COND

Given one of the following references:

a. Laboratory control guide for plant in question.

b. (See page 104, Appendix I.)

Given charts, nomographs, standard curves, calculator, laboratory logbooks.

PL

80% of abnormal conditions must be spotted and corrected to meet performance level in objectives 1-7.

Environmental Science 204
3 CREDITS

WATER QUALITY LABORATORY MANAGEMENT II

The purpose of this course is to aid the student in the design and implementation of a monitoring and surveillance program. This will include selecting sampling points, times of sampling, types of samples, organizing the program logistics, collecting samples, transporting and preserving samples, preparing reports, interpreting data, and suggesting actions to take. The student will learn how to select, fill out, and submit reports required by local, state, and federal legislation.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ

List at least eight steps in the design and implementation of monitoring and surveillance programs.

COND

For each of the following types of programs (using reference materials):

1. Establishment of a base-line record of water quality.
2. Investigation of suitability as a source of municipal, industrial, or other water supply.
3. Investigation of suitability for recreational use.
4. Investigation of suitability for propagation of aquatic life.
5. Day to day monitoring of raw water sources of municipal, industrial, and other water supply.
6. Monitoring effects of waste discharges.
7. Surveillance to detect adherence to or violation of water quality standards.
8. Detection of sudden changes in water quality caused by slugs of wastes resulting from spills, deliberate discharges, or treatment plant failures.
9. Determination of patterns of pollution downstream from waste discharges and effects on water uses.
10. Determination of adherence to or violation of water quality standards.
11. Determination of characteristics and rates of natural purification of streams.
12. Projection of effects of pollution on conditions of flow and temperature other than those occurring during study.
13. Estimation of waste assimilation capacities of streams.
14. Estimation of reductions in waste loads necessary to meet water quality requirements.
15. Determination of causes of fish kills or other disasters involving deterioration of water quality.
16. Determination of existing water quality before some change in conditions, such as a new or increased waste discharge or impoundment of a reservoir.

PL

List must include the following, as appropriate:

1. Historical data on sample area.
2. Physical characteristics of stream:
    a. Mixing.
        1) vertical.
        2) lateral.
        3) longitudinal.
        4) tidal.
    b. Reaeration.
    c. Sludge deposits.
    d. Biological accumulation.
3. Selection of sampling stations:
    a. Depth.
    b. Frequency.
    c. Accessibility.
    d. Points in cross section.

e. Effect of time of day, week, season, year.

4. Sampling procedures:
   a. Person collecting.
   b. Site identification.
   c. Container and equipment preparation.
   d. Timing.
   e. Preservation.
   f. Transportation.
   g. Note taking.
   h. Cleaning equipment.

5. Sampling routine:
   a. Number of samples.
   b. Duration of sampling.
   c. Frequency.
   d. Automated continuous sampling.

6. Stream flows:
   a. Variation with day, week, season, year.
   b. Drought periods.
   c. Flood periods.
   d. Controlled periods.
   e. Selection of sampling periods.
   f. Sources of data.

7. Time-of-water travel:
   a. Approximation.
   b. Floats.
   c. Cross sections.
   d. Tracers.

8. Laboratory:
   a. Mobile laboratory.
   b. Fixed laboratory.
   c. Supplies and equipment.
   d. Work loads.
   e. Data tabulation.

9. Sources of information:
   a. State pollution control agencies.
   b. Other state agencies.
   c. EPA.
   d. USGS.
   e. Other federal agencies.
   f. Water and wastewater treatment plants.

10. Interpretation of data:
   a. Organization of data.
   b. Biometrics:
      1) study design: (a) randomization; (b) sample size; (c) subsampling.
      2) graphic examination: (a) raw data; (b) frequency histograms; (c) frequency polygon; (d) cumulative frequency; (e) two-dimensional graphs.
      3) sample means and variance: (a) stratified random samples; (b) subsamples; (c) rounding.
      4) tests of hypotheses: (a) t-test; (b) Chi-square test; (c) F-test; (d) analysis of variance.
      5) confidence intervals for means and variances.
      6) linear regression and correlation: (a) tests for hypotheses; (b) regression for bivariate data; (c) linear correlation.

11. Report preparation:
   a. Tables.
   b. Graphics.
   c. Maps.
   d. Photographs.
   e. Text.

Environmental Science 205
3 CREDITS

WATER QUALITY LABORATORY TECHNIQUES V

The purpose of this course is to assist the student in learning to make measurements for volume, quantity of flow, time of flow, cross sectional area of stream, and velocity for bodies of water, using such instruments as Pygmy current meter, Price current meter, staff gauge, float recorder, weirs, Venturi meter, Parshall flume, Kenningson nozzle, and orifice meter.

WHEN YOU COMPLETE THIS COURSE, YOU WILL BE ABLE TO:

1

OBJ
Select measuring device.

COND
Given one of the following measurements to make:
a. Volume.
b. Quantity of flow.
c. Time of flow.
d. Cross-sectional area.
e. Velocity.
Given the following instruments:
a. Tape.
b. Staff gauge.
c. Pygmy current meter.
d. Price current meter.
e. Float recorder.
f. V-notch weir.
g. Rectangular weir.
h. Venturi meter.
i. Parshall flume.
j. Kenningson nozzle.
k. Orifice meter.

PL
90% of selections must meet given accuracy and precision requirements.

2

OBJ
Calibrate measuring instrument, or when appropriate, ship to manufacturer.

COND
Given:
a. Manufacturer's guide
b. One of following instruments:
1. Pygmy current meter.
2. Price current meter.
3. Float recorder.

PL
Instrument must meet accuracy and precision requirements of manufacturer 95% of the time.

3

OBJ
Make measurement of flow condition.

COND
Given one of the following measurements to make:
a. Volume.
b. Quantity of flow.
c. Time of flow.
d. Cross-sectional area.
e. Velocity.
Given the following instruments:
a. Tape.
b. Staff gauge.
c. Pygmy current meter.
d. Price current meter.
e. Float recorder.
f. V-notch weir.
g. Rectangular weir.
h. Venturi meter.
i. Parshall flume.
j. Kenningson nozzle.
k. Orifice meter.

PL
90% of measurements must be within range of precision and accuracy of that made by another competent technician.

4

OBJ
Calculate results of flow measurement

and prepare and interpret data.

COND

Given:

a. Results of measurement.

b. Tables, charts, nomographs, calculator, computer program, and computer.

c. Graph paper.

d. Report preparation guide.

PL

95% of calculations and form of presentation must be that required by regulatory agency or plant management.

Appendix

Appendix I

REFERENCE MATERIAL FOR NPDES TESTS

1. Standard Methods for the Examination of Water and Wastewater, APHA, WPCF, AWWA. ASCE 13th ed. (1971).

2. Annual Book of Standards, Part 23, Water, Atmospheric Analysis, ASTM (1972).

3. Methods for Chemical Analyses of Water and Wastes. EPA (1971).

4. National Bureau of Standards, "Standards on Laboratory Glassware."

Appendix II
NPDES TESTS

1. Alkalinity
2. BOD_5
3. COD
4. Total solids
5. Total dissolved solids
6. Total suspended solids
7. Total volatile solids
8. Ammonia
9. Kjeldahl nitrogen
10. Nitrate
11. Total phosphorus
12. Acidity
13. Total organic carbon
14. Hardness
15. Nitrite
16. Aluminum
17. Antimony
18. Arsenic
19. Barium
20. Beryllium
21. Boron
22. Cadmium
23. Calcium
24. Chromium VI
25. Chromium total
26. Cobalt
27. Copper
28. Iron
29. Lead
30. Magnesium
31. Manganese
32. Mercury
33. Molybdenum
34. Nickel
35. Potassium
36. Selenium
37. Silver
38. Sodium
39. Thallium
40. Tin
41. Titanium
42. Vanadium
43. Zinc
44. Organic Nitrogen
45. Orthophosphate
46. Sulfate
47. Sulfide
48. Sulfite
49. Bromide
50. Chlorine
51. Cyanide
52. Fluoride
53. Chlorine
54. Oil and grease
55. Phenols
56. Surfactants
57. Algicides
58. Benzidine
59. Chlorinated organic compounds
60. Pesticides

61. Color
62. Specific conductance
63. Turbidity
64. Alpha, total
65. Beta, total
66. Radium
67. Fecal streptococci
68. Fecal coliform
69. Total coliform

Appendix III

UNIT PROCESSES IN TREATMENT PLANTS

1. Collection system
2. Prechlorination
3. Screening and grinding
4. Grit collection
5. Primary sedimentation
6. Trickling filter
7. Aeration
8. Secondary sedimentation
9. Stabilization pond
10. Primary digestion
11. Secondary digestion
12. Thickening
13. Sludge conditioning
14. Vacuum filtration
15. Centrifugation
16. Chlorination
17. Chemical treatment
18. Sand filtration
19. Activated carbon
20. Reverse osmosis
21. Electrodialysis
22. Ozonization
23. Hyperfiltration
24. Ion exchange
25. Distillation

Appendix IV*

EQUIPMENT AND SUPPLIES FOR A WASTEWATER LABORATORY

A. Equipment

1. Clock, interval timer
2. Deionizer
3. Refrigerator, at least 10 cubic-foot capacity
4. BOD incubator
5. Water still
6. pH meter
7. Balance, triple beam
8. Balance, analytical
9. Desiccator
10. Drying oven
11. Muffle furnace
12. Pressure-vacuum pump
13. Bunsen burner
14. Hot plate
15. Water bath
16. Spectrophotometer
17. Kjeldahl apparatus, digestion
18. Kjeldahl apparatus, distillation
19. Gas analysis (CO_2)
20. Wastewater sampler
21. Chlorine colorimeter
22. Amperometric titrater
23. Condenser
24. Microscope and light
25. Sterilizer
26. 44.5°C incubator

B. General Supplies

1. Apron
2. Brushes
3. Funnels
4. Spatula
5. Wax pencils
6. Lubricants
7. Glassware cleaner
8. Face shield
9. Neoprene gloves
10. Graph paper

C. Analytical Supplies

1. Sample bottles
2. BOD bottles
3. Wash bottles
4. Dropping bottles
5. Test tubes
6. Nessler tube
7. Erlenmeyer flask
8. Volumetric flask
9. Filtering flask
10. Kjeldahl flask
11. Round bottom flask
12. Separatory funnel
13. Buchner funnel

*This list of equipment and supplies is for a "typical" wastewater or water quality control laboratory. However, the instructor should select from the list those items that apply to the NPDES tests and should not expect to have all the equipment and supplies. The instructor may also have to obtain materials not found on the list but which are necessary for NPDES tests.

14. Funnel support
15. Buret and caps
16. Buret clamp
17. Buret support
18. Gooch crucible
19. Crucible holder
20. Crucible tongs
21. Pipets
22. Safety pipet filler
23. Beakers
24. Graduated cylinder
25. Evaporating dish
26. Petri dish
27. Opal glass plate
28. Glass fiber filter disc
29. Glass beads
30. Rubber stoppers
31. Rubber tubins
32. Utility clamp
33. Tripod
34. Filter paper
35. Thermometer

D. Chemical Supplies

1. Methylene blue solution
2. Buffer solution
3. Phenolphthalein indicator
4. Thymol blue indicator
5. Methyl orange indicator
6. Manganous sulfate
7. Sodium thiosulfate
8. Starch
9. Calcium chloride
10. Ferric chloride
11. Magnesium sulfate
12. Phosphate buffer
13. Ferrous ammonium sulfate
14. Potassium dichromate
15. Sulfuric acid-silver sulfate
16. Ammonium chloride
17. Nessler reagent
18. Rochelle salt
19. Zinc sulfate
20. Sodium arsenite
21. Standard nitrate solution
22. Boric acid
23. Sodium hydroxide
24. Sodium thiosulfate
25. Sulfuric acid-mercuric sulfate-potassium sulfate
26. N-Butanol reagent
27. Chloroform
28. Alkaline iodide azide
29. Potassium iodide
30. Arsenite
31. Sodium sulfate
32. Brucine-sulfanilic acid
33. Mercuric sulfate
34. Sodium hydroxide-sodium thiosulfate
35. Calcium chloride
36. Silicic acid
37. Sulfuric acid
38. Ferrion indicator solution
39. Zonite
40. Potassium chromate
41. Silver nitrate